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An Assessment of the Accuracy of the Manitoba General Moose Hunter Questionnaire Survey

By Soprovich, Daniel W. 1989.

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ABSTRACT

The objective of this study was to evaluate the accuracy of the standard mailed questionnaire method used to estimate the general moose (Alces alces) harvest. The standard method for estimating harvest was simulated by sending one questionnaire to a systematic sample of 2551 general moose licensees. A second questionnaire was sent to licensees who had not responded within 30 days. Harvest data were obtained from 86.8% of the random sample of 250 licensees who did not respond to either questionnaire. License stubs received by 20 January 1987 comprised group I and license stubs received between 20 January and 20 February 1987 comprised group II. Response rate to the first mailing was 46.3% for group I and 46.5% for group II. Response rate to both mailings was 59.3% for group I and 57.4% for group II. Licensees from group I differed from those from group II for a number of harvest statistics including success rate. Respondents to the first mailing differed from those to the second for several statistics. Non-respondents and respondents differed for a number of harvest statistics including higher success and kill rates for respondents. Total harvest was estimated at 950 ± 106 moose when the kill rate of non-respondents was incorporated. It was estimated that the standard method overestimated moose harvest by 15.2% for the early season, 43.0% for the late season, 23.7% for both seasons combined, and 64.4% for Game Hunting Area 26. Linear extrapolation with successive waves resulted in estimated harvest overestimates of 2.1% for the early season, 3.5% for the late season, and 2.6% for both seasons combined. Total harvest was estimated at 936 moose when it was assumed that kill rate decreases with sampling completeness. Ambiguous questionnaires represented 18.6% and 26.0% of questionnaires from the first and second mailing respectively and influenced a number of harvest statistics. The frequency of reasons for not responding are detailed.

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INTRODUCTION

The Manitoba Wildlife Branch has collected information relative to the harvest of game populations for many years. An early method relied upon hunters to voluntarily submit a questionnaire appended to their license. This method resulted in return rates which were generally between 20-30% of the outstanding licenses (Bossenmaier and MacPherson 1964). An estimate of total harvest was generated using the assumption that the data supplied by the hunters who returned their questionnaires (respondents) were representative of the data for the hunters who did not return their questionnaires (non-respondents). Bossenmaier and MacPherson (1964) indicated that available evidence did not support this assumption and that the successful hunter was more inclined to return a questionnaire. This condition would lead to an overestimate of total harvest.

MacPherson (1963, cited by Bossenmaier and MacPherson 1964) investigated the accuracy of the white-tailed deer (Odocoileus virginianus) harvest estimates generated by the above method for 1962. These estimates were compared to those generated from a random sample of 5% of the deer hunters. These hunters were mailed as many as 3 questionnaires dependent upon whether they had responded. A subsequent telephone interview or personal interview of non-respondents resulted in a combined response rate of 96.8% of the sample. MacPherson (1963, cited in Bossenmaier and MacPherson 1964) found that the harvest estimate generated by the license questionnaire method was considerably higher than that generated by the mailed questionnaire method. The estimate generated by the mailed questionnaire method was believed to have been the most reliable estimate.

The license questionnaire method and the mailed questionnaire method were utilized to generate harvest estimates for the majority of species hunted during 1963. An attempt was made to randomly select 10% of the resident moose (Alces alces) hunters during 1963 (Bossenmaier and MacPherson 1964). The non-resident moose hunters were sampled at a rate of approximately 90%. These hunters were mailed as many as 3 questionnaires dependent upon whether they had responded. The return rates after 3 questionnaires were 89% for resident moose hunters and 86% for non-resident moose hunters. These rates were considerably higher than the combined

return rate of 21.3% for the license questionnaire method.

The mailed questionnaire method resulted in a harvest estimate of 1580 moose while the license questionnaire method resulted in a harvest estimate of 2771 moose (Bossenmaier and MacPherson 1964). The estimate generated by the mailed questionnaire method was considered to be most accurate (Bossenmaier and MacPherson 1964). It likely was considerably more accurate given the substantially greater response rate for the mailed questionnaire method. The mailed questionnaire method has been utilized to generate harvest estimates for moose since 1963.

The mailed questionnaire method presently used to generate harvest estimates for moose varies relative to sampling intensity and number of mailings (questionnaires) for both special (draw) moose licensees and general moose licensees. Special moose licensees may hunt moose in only 1 (or 2) Game Hunting Area(s). The sampling intensity of these special moose licensees varies between 50% and 100% dependent upon the number of licenses issued for the respective Game Hunting Area(s). A second questionnaire is mailed to non-respondents approximately 1 month following the initial mailing. A general moose licensee may hunt in a number of Game Hunting Areas (variable between years but 22 for 1986). The most recent method has been to mail 1 questionnaire to a systematic sample of approximately 50% of the general moose licensees.

The questionnaire method provides an estimate with 95% confidence limits for the number of moose harvested by general moose licensees. Recent annual harvest reports include reported information by Game Hunting Area but do not include estimates of harvest by Game Hunting Area. The management of moose in Manitoba is based upon the Game Hunting Area geographic unit (eg., populations are estimated by specific Game Hunting Area) hence the information reported by general moose licensees is often used by managers to estimate harvest by Game Hunting Area. The accuracy of such estimates has been the subject of considerable discussion. Comparison of such estimates for Game Hunting Area 26 to estimates based upon roadside check stations has led V. Crichton (Manitoba Wildlife Branch, pers. commun.) to believe that the questionnaire-based estimates are extremely inaccurate.

Estimates of game harvest by the questionnaire method have been found to be sensitive to response rate (see Filion 1980). A low response

rate may result in an inaccurate estimate of harvest. A goal of the present study was to examine the accuracy of the total harvest estimate generated for the general moose licensees. A second and critical goal of the present study was to examine the questionnaire method for systematic bias which might influence estimates generated for specific Game Hunting Areas.

METHODS

The general moose hunter questionnaire study encompassed 2 discrete tasks. The first task was to provide harvest estimates which were derived in a manner similar to past estimates. These harvest estimates could then be used by game managers for comparative purposes. The standard method for estimating harvest by general moose licensees was followed. License stubs were sampled at the 50% level as they were received from Wildlife and Fisheries Licensing. A questionnaire was sent to each of the general moose licensees in this sample. An example of a questionnaire and the accompanying information is contained in Appendix I. The questionnaire is essentially a postage-paid card.

The primary task for the general moose hunter questionnaire study was to examine the accuracy of the estimates generated by the questionnaire method. A second questionnaire was sent to those licensees from whom a response had not been received by 30 days post mailing of the first questionnaire. It was possible to accomplish this task because each questionnaire was individually numbered and a master list had been created of the complete sample. The purpose of the second questionnaire was to assess the impact of a second questionnaire on response rate and subsequent harvest estimates. The final estimates from questionnaire-generated data are based upon questionnaires received by approximately 30 April (C. Hummelt, Manitoba Wildlife Branch, pers. commun.). The estimates generated for the 1986 moose licensees were based upon questionnaires received by 30 April 1987.

License stubs are received by the Wildlife Branch after vendors have returned them to Wildlife and Fisheries Licensing and after Wildlife and Fisheries Licensing has processed them. Vendors are sometimes tardy with their returns such that Wildlife and Fisheries Licensing may have to

remind vendors to submit their stubs. As a consequence, stubs are received by the Wildlife Branch continuously over a period of months.

License stubs received by 20 January 1987 were systematically sampled and questionnaires were mailed out on that date. This group of sampled hunters is referred to as Group I in subsequent discussion. License stubs received after 20 January 1987 were sampled until 20 February 1987 when questionnaires for this group were mailed out. This group of sampled hunters is referred to as Group II in subsequent discussion.

Some license stubs were received too late to provide time for questionnaires to be received and data to be included in final estimates. A questionnaire was mailed to each of these licensees (100% sampling intensity) on 16 April 1987, with a second questionnaire being mailed to non-respondents on 15 June 1987. This group is referred to as Group III in subsequent discussion.

An initial questionnaire was sent to a fourth group of hunters on 15 June 1987, but no second questionnaire was sent to the non-respondents from this group. This group is referred to as Group IV in subsequent discussion. An additional group of stubs was received in July 1987. No questionnaires were sent to this group of hunters which is referred to as Group V in subsequent discussion. The purpose for sampling groups III and IV was to determine how closely their data compared to that of the group of licensees who had the opportunity to be included in the estimates (Groups I and II).

Hunters sometimes returned both questionnaires. If the questionnaire from the first mailing was returned first, the questionnaire from the second mailing was deleted. Conversely, the questionnaire from the second mailing was utilized if received first.

It was possible to determine which mailing a questionnaire was from for some questionnaires with illegible numbers. The questionnaires from the first mailing were then utilized in the analysis of response to one questionnaire alone (i.e., the simulation of the results under normal sampling procedure). These questionnaires were not utilized in comparing groups and mailings because it was not possible to determine if an individual had responded to 1 or 2 questionnaires or which individuals among the non-respondent group had returned such a questionnaire.

Those licensees from groups I and II from whom a questionnaire had not been received by 30 April 1987 were treated as the non-respondents. A sample of 250 of these non-respondents was selected randomly. An attempt was made to contact each hunter by telephone. Some individuals in the sample could not be contacted by telephone and an attempt to contact them personally was made by Natural Resource Officers, Regional Wildlife Technicians, and the author. The non-respondents were asked the questions detailed in Appendix II. These questions included those on the questionnaire and several additional questions.

Harvest estimates and confidence limits were calculated according to Hummelt (1986) for the group which simulated the standard method. Harvest estimates and confidence limits were calculated using the method of Hansen and Hurwitz (1946) when data from non-respondents was incorporated. The variance estimate from formula (2) of Hansen and Hurwitz (1946) was estimated as $\hat{p}\hat{q}$ with $\hat{p}$ being the estimate for the complete sample of questionnaires (i.e., incorporating data from respondents and non-respondents).

The use of successive groups (waves) of respondents has been used to calculate estimates believed to be relatively free of non-response bias (see Filion 1980). This method involves the calculation of point estimates for the statistic of interest at different levels of total response (eg., at 50% response, 60% response, 80% response, etc.). A line of best fit is then calculated (treating the estimator as the dependent and % return as the independent variables) via the method of least squares linear regression. The statistic is then estimated (extrapolated) for a response rate of 100% (complete response).

Waves are determined as related to time beyond first mailing and the relationship between response rate and time (F. Filion, Environment Canada, pers. commun.). Wave I will include data (questionnaires) received until a certain date after the date of the first mailing (eg., questionnaires received within 3 weeks after the date of the first mailing). Wave II will include data received after that included in Wave I but before that utilized for Wave III (eg., questionnaires received within the 3 to 6 week period after the date of the first mailing). Each successive wave consists of the data received within a unique period of time. Waves

therefore are related to time and not mailing.

The method utilized to estimate moose harvest in this study is different in that mailing number (rather than time directly) was used to determine wave (i.e., Wave I consisted of respondents to the first mailing and Wave II consisted of respondents to the second mailing). It was not necessary to use linear regression to calculate a line of best fit because only two data points (waves) were available. The equation for the line was calculated using the two available data points as follows:

$$b \text{ (slope)} = \frac{Y_2 - Y_1}{X_2 - X_1} \text{ and a (intercept)} = Y_1 - bX_1 \text{ (for } X_1, Y_1).$$

The method used to calculate the kill rate by moose hunters at 100% response (2551 questionnaires) was also calculated somewhat differently in that the number of questionnaires was used as the independent variable rather than the percentage response (both methods result in the same estimate).

RESULTS

The majority of license stubs had been received by 20 January 1987 when the first questionnaire of group I was sent (Table 1). The response rate to the second mailing (24.1%) was adjusted for those responses to the first mailing received after 19 February 1987. A second mailing increased response rate by approximately 13% (response rate to both mailings less response rate to first mailing).

Response rate to the first questionnaire was not different between groups at 1 month post mailing (two-tailed test; $z = 0.87$; $n_1 = 2063$, $n_2 = 488$; $P > 0.05$) or 30 April 1987 (two-tailed test; $z = -0.07$; $n_1 = 2063$, $n_2 = 488$; $P > 0.05$). The response rate to 2 mailings was not different between groups (two-tailed test; $z = 0.77$; $n_1 = 2063$, $n_2 = 488$; $P > 0.05$). It is estimated that the second mailing increased the response rate by 10.9% for group II.

The response rate to 2 mailings for Group III was comparable to that for groups I and II. The response rate to 1 mailing was low for group IV and a second mailing was not conducted because of the poor response rate and the few hunters in the group. The 8 stubs received in July were not

Table 1. Sampling procedure for the 1986 general moose hunter questionnaire.

Group	Number of license stubs	Sampling intensity (%)	Number of stubs sampled	Date questionnaire mailed	Number of questionnaires returned by second mailing	Response rate (%)	Number of questionnaires returned by 30 April 1987	Response rate (%)
I	4126	50	2063	20 January 1987	831	40.3	956	46.3
			1233[a]	19 February 1987	N/A		267	24.1[b]
				Both questionnaires together	N/A		1223	59.3
II	976	50	488	20 February 1987	186	38.1	227	46.5
			302[a]	20 March 1987[c]	N/A		53	20.3[b]
				Both questionnaires together	N/A		280	57.4
III	98	100	98	16 April 1987	50	51.0	50[d]	51.0
			48[a]	15 June 1987	N/A		5[d]	10.4
				Both questionnaires together	N/A		55[d]	56.1
IV	26	100	26	15 June 1987	N/A		5[d]	19.2
V	8	0	N/A					

[a]Equivalent to the number of non-respondents at the date of the second mailing.
[b]Calculation adjusted for the respondents to the first questionnaire who were mailed a second questionnaire.
Example - Group I - Response Rate = $\frac{267}{1233 - (956 - 831)}$
[c]Questionnaires sent out on 20 March 1987 because mailing date (22 March 1987) fell on a Sunday.
[d]Number of questionnaires results from returns after 30 April 1987 for these groups.

sampled because they were few in number.

The total number of license stubs received by Wildlife and Fisheries Licensing as of 14 December 1987 was 5374 (D. Tuck, Manitoba Department of Natural Resources, pers. commun.). This is 140 more license stubs than is accounted for in Table 1. The missing license stubs represent 2.6% of all the license stubs and were lost between Wildlife and Fisheries Licensing accounting for them and being received by the author. These stubs do not represent stubs which arrived after 15 June 1987 because the magnitude of the discrepancy was apparent on 23 April when it was indicated that 5354 stubs had already been processed by Wildlife and Fisheries Licensing (J. Rurak, Manitoba Department of Natural Resources, pers. commun.).

In a number of cases, questionnaires from both mailings were returned by an individual hunter. The questionnaire from the first mailing was returned prior to the questionnaire from the second mailing in 78% of these cases (Table 2).

Table 2. The number of cases where a questionnaire from the first mailing or the second mailing was received prior to a questionnaire from the other mailing.

Group	Number of cases	
	Questionnaire from first mailing received prior to questionnaire from second mailing	Questionnaire from second mailing received prior to questionnaire from first mailing
I	22	9
II	14	1

The number was not legible on some of the returned questionnaires (Table 3). This occurred because individuals cut the number out (1 case) or intentionally made it illegible (several cases). The majority of cases where the numbers were illegible resulted from the number being damaged when the envelope which contained the questionnaire was torn off. It was

possible to determine mailing for 19 of the 28 questionnaires with illegible numbers.

Table 3. Number of questionnaires with illegible numbers.

Group	Number of questionnaires		
	First mailing	Second mailing	Unknown
I	14	1	
II	4		
Unknown			9

Relationship Between Response Rate and Time

Table 4 details the rate at which responses were received by the Wildlife Branch for group I. The total number of questionnaires indicated as having been returned for the first mailing is 952 in Table 4 when it should have been 956 (see Table 1). This small discrepancy likely resulted from the date of return not having been recorded for several questionnaires.

Some questionnaires were returned after 30 April; however, they were relatively few in number. Approximately 79% of the questionnaires were returned by 21 days and approximately 86% of the questionnaires returned by 28 days after the date of the first mailing. For the second mailing, approximately 58%, 81%, and 90% of total returns were received by 14, 21, and 28 days respectively post mailing.

Simulation of Normal Procedure

The simulation of the standard method utilized only questionnaires returned from the first mailing by 30 April 1987 (956 from group I, 227 from group II, 18 identified to first mailing). This group of data were input into the computer for analysis by Brian Knudsen. The sample size for this group should have been 1201 questionnaires; however, output indicated a small, insignificant discrepancy (Table 8, n = 1203).

The total number of days spent hunting, harvest, mean number of

Table 4. Number of questionnaires returned by date between 12 February and 30 April of 1987. Data is for Group I only.

Date	First mailing				Second mailing			
	Number of questionnaires returned[a,b]	Cumulative number of questionnaires returned[a,b] (% of total)	Cumulative number of days since mailing	Number of questionnaires for which a previous questionnaire had been returned	Number of questionnaires returned[a]	Cumulative number of questionnaires returned[a] (% of total)	Cumulative number of days since mailing	Number of questionnaires for which a previous questionnaire had been returned
Prior to 12 February	748	748(79)						
12	15	763(80)	23					
13	12	775(81)	24					
17	40	815(86)	28					
18	7	822(86)	29					
19	9	831(87)	30					
20	1	832(87)	31					
23	11	843(89)	34					
24	15	858(90)	35		1	1(<1)	5	
25	8	866(91)	36		10	11(4)	6	
27	15	881(93)	38		61	72(27)	8	6
2 March			41		1	73(27)	11	
3	13	894(94)	42		55	128(48)	12	1
4	9	903(95)	43		25	153(57)	13	3
5	3	906(95)	44		3	156(58)	14	4
6	10	916(96)	45		27	183(69)	15	1
7			46		1	184(69)	16	
8	2	918(96)	47				17	
9	5	923(97)	48		6	190(71)	18	1
11	5	928(97)	50	1	13	203(76)	20	1
12	3	931(98)	51	1	12	215(81)	21	
16	3	934(98)	55		6	221(83)	25	
17	2	936(98)	56		14	235(88)	26	
19	2	938(99)	58	1	5	240(90)	28	1

Table 4. (Continued)

Date	First mailing				Second mailing			
	Number of questionnaires returned[a,b]	Cumulative number of questionnaires returned[a,b] (% of total)	Cumulative number of days since mailing	Number of questionnaires for which a previous questionnaire had been returned	Number of questionnaires returned[a]	Cumulative number of questionnaires returned[a] (% of total)	Cumulative number of days since mailing	Number of questionnaires for which a previous questionnaire had been returned
23 March	3	941(99)	62					
24	2	943(99)	63		3	243(91)	32	
25			64		1	244(91)	33	1
26	2	945(99)	65				34	1
30	3	948(100)	69		1	245(92)	35	
31			70		5	250(94)	39	
2 April			72	1	2	252(94)	40	
3			73				42	
8	2	950(100)	78		2	254(95)	43	
10			80		6	260(97)	48	
13			83		1	261(98)	50	
15	1	951(100)	85		1	262(98)	53	
16	1	952(100)	86		1	263(99)	55	
21							56	
23					1	264(99)	61	
28					1	265(99)	63	
					2	267(100)	68	

[a]Includes only questionnaires for which a questionnaire from a different mailing had not been received.
[b]Total number of questionnaires was 952 for this calculation.

days hunted per hunter, success rate, and mean number of days to kill and tag a moose are summarized for reported information by season and for both seasons combined (Tables 5, 6, 7). Some of the questionnaires contained ambiguous information or were not complete - this information was handled using the rules detailed in Appendix III. It should be noted that Table 5 (early season) contains data indicating that licensees hunted in Game Hunting Areas 8, 16, and 26 which were not open during the early season. Table 6 (late season) contains data indicating that licensees hunted in Game Hunting Areas 6A, 17, and 19A which were not open during the late season. Although Game Hunting Areas 1, 2, and 3 had only 1 season (1 September to 20 December), hunters could respond as having hunted in the early season (September to November) or late season (December) on the questionnaire. Licensees who hunted in these Game Hunting Areas have been included in both Tables 5 and 6 as a result. Table 5 indicates that 1 adult female moose was killed in G.H.A. 21 (adult males were the only legal age-sex class for this season).

The majority (91.4%) of license purchasers chose to hunt (Table 8). A greater proportion of licensees hunted during the early season (70.9%) than the late season (36.5%). Estimates in Table 8 were based on 5354 licenses having been purchased which is the figure available from Wildlife and Fisheries Licensing to 30 April 1987. The estimated harvests with 95% confidence limits were 765 ± 102 moose for the early season, 409 ± 74 moose for the late season, and 1175 ± 124 moose for both seasons. The majority of moose harvested were estimated to have been adult males (1099 ± 121).

Group I - First Mailing

Tables 9 to 11 present reported information and means for the early, late, and combined seasons for those licensees from group I who responded to the first mailing. The rules detailed in Appendix IV were used to handle questionnaires with ambiguous or incomplete information for analysis of groups other than the simulated group. It should be noted that 1 adult female and 1 immature female were reported harvested in Game Hunting Area 21 during the early season and 1 immature male was reported harvested in Game Hunting Area 11 during the late season (adult males were

Table 5. Simulated group. Reported information and means for the early season (from Knudsen).

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	29	147	0						5.07	0	
1	11	52	6		3	3			4.73	.55	8.67
2	3	14	1		1				4.67	.33	14.00
2A	17	88	4		4				5.18	.24	22.00
3	26	239	10		5	4	1		9.19	.38	23.90
4	22	126	4		4				5.73	.18	31.50
5	31	194	4		4				6.26	.13	48.50
6A	13	86	4		4				6.62	.31	21.50
7	50	268	12		12				5.36	.24	22.33
7A	49	298	7		7				6.08	.14	42.57
8	1	4	0						4.00	0	
9	208	1246	41		41				5.99	.20	30.39
10	39	173	4		4				4.44	.10	43.25
11	9	39	1		1				4.33	.11	39.00
12	43	197	9		9				4.58	.21	21.89
14	66	299	6		6				4.53	.09	49.83
15	30	136	3		3				4.53	.10	45.33
15A	17	60	1		1				3.53	.06	60.00
16	2	6	0						3.00	0	
17	38	170	11		11				4.47	.29	15.45
17A	70	336	13		13				4.80	.19	25.85
19A	26	134	8		8				5.15	.31	16.75
21	85	406	12		11	1			4.78	.14	33.83
21A	49	260	10		10				5.31	.20	26.00
26	11	38	1		1				3.45	.09	38.00
Total	853[b]	5016	172	0	163	8	1	0	5.88	.20	29.16

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 6. Simulated group. Reported information and means for the late season (from Knudsen).

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	16	74	4	2	1	1			4.63	.25	18.50
1	3	8	1		1				2.67	.33	8.00
2	2	9	0						4.50	0	
3	1	10	0						10.00	0	
4	7	25	1		1				3.57	.14	25.00
5	12	48	1		1				4.00	.08	48.00
6A	2	16	0						8.00	0	
7	16	53	2		2				3.31	.12	26.50
7A	8	33	2		2				4.13	.25	16.50
9	62	226	8	1	3	2	1	1	3.65	.13	28.25
10	10	35	5		5				3.50	.50	7.00
11	3	4	1		1				1.33	.33	4.00
12	41	193	6		6				4.71	.15	32.17
14	77	388	23		23				5.04	.30	16.87
15	6	17	1		1				2.83	.17	17.00
15A	1	6	0						6.00	0	
17	10	33	3		3				3.30	.30	11.00
17A	23	90	4		4				3.91	.17	22.50
19A	2	9	0						4.50	0	
21	34	136	2		2				4.00	.06	68.00
21A	21	84	2		2				4.00	.10	42.00
26	106	538	26		26				5.08	.25	20.69
Total	439[b]	2035	92	3	84	3	1	1	4.64	.21	22.12

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 7. Simulated group. Reported information and means for both seasons combined (from Knudsen).

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	45	221	4	2	1	1			4.91	.09	55.25
1	14	60	7		4	3			4.29	.50	8.57
2	5	23	1		1				4.60	.20	23.00
2A	17	88	4		4				5.18	.24	22.00
3	27	249	10		5	4	1		9.22	.37	24.90
4	29	151	5		5				5.21	.17	30.20
5	43	242	5		5				5.63	.12	48.40
6A	15	102	4		4				6.80	.27	25.50
7	66	321	14		14				4.86	.21	22.93
7A	57	331	9		9				5.81	.16	36.78
8	1	4	0						4.00	0	
9	270	1472	49	1	44	2	1	1	5.45	.18	30.04
10	49	208	9		9				4.24	.18	23.11
11	12	43	2		2				3.58	.17	21.50
12	84	390	15		15				4.64	.18	26.00
14	143	687	29		29				4.80	.20	23.69
15	36	153	4		4				4.25	.11	38.25
15A	18	66	1		1				3.67	.06	66.00
16	2	6	0						3.00	0	
17	48	203	14		14				4.23	.29	14.50
17A	93	426	17		17				4.58	.18	25.06
19A	28	143	8		8				5.11	.29	17.88
21	119	542	14		13	1			4.55	.12	38.71
21A	70	344	12		12				4.91	.17	28.67
26	117	576	27		27				4.92	.23	21.33
Total	1100[b]	7051	264	3	247	11	2	1	6.41	.24	26.71

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the columns because hunters can hunt in more than one Game Hunting Area.

Table 8. Simulated group. Estimates and information necessary to estimation for the early and late seasons and both seasons combined (from Knudsen).

Season	Number of licenses sold[a]	Total number of responses	Number of respondents who hunted	Estimates					
				Number of hunters	Harvest (± 95% confidence limits)[b]				
					Total	Unknown	Adult male	Adult female	Immature male[c]	Immature female[c]
Early	5354	1203	853	3796	765(102)	0	725(100)	36(25)	4(9)	0
Late	5354	1203	439	1954	409(74)	13(15)	374(72)	13(15)	4(9)	4(9)
Both	5354	1203	1100	4896	1175(124)	13(15)	1099(121)	49(29)	9(12)	4(9)

[a]Based on number of licenses returned by 30 April 1987.
[b]Confidence limits incorporate finite correction factor (see Hummelt 1986).
[c]Immature moose refer to calves.

Table 9. Group I - first mailing. Reported information and means for the early season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	28	166	1			1			5.93	.04	166.00
1	10	48	5		3	2			4.80	.50	9.60
2	3	15	0						5.00	0	
2A	15	84	3		3				5.60	.20	28.00
3	25	243	10		5	4	1		9.72	.40	24.30
4	24	140	5		5				5.83	.21	28.00
5	29	160	4		4				5.52	.14	40.00
6A	13	88	4		4				6.77	.31	22.00
7	43	226	8		8				5.26	.19	28.25
7A	43	259	6		6				6.02	.14	43.17
9	195	1208	38		38				6.19	.19	31.79
10	32	145	4		4				4.53	.13	36.25
11	9	39	1		1				4.33	.11	39.00
12	40	190	6		6				4.75	.15	31.67
14	51	231	3		3				4.53	.06	77.00
15	26	113	3		3				4.35	.12	37.67
15A	12	48	1		1				4.00	.08	48.00
17	32	141	8		8				4.41	.25	17.63
17A	64	310	14		14				4.84	.22	22.14
19A	25	136	8		8				5.44	.32	17.00
21	74	350	11		9	1	1		4.73	.15	31.82
21A	43	220	10		10				5.12	.23	22.00
Total	727[b]	4560	153	0	143	8	2	0	6.27	.21	29.80

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 10. Group I - first mailing. Reported information and means for the late season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	8	38	1		1				4.75	.12	38.00
1	3	8	0						2.67	0	
2	1	1	0						1.00	0	
3	1	10	0						10.00	0	
4	5	14	0						2.80	0	
5	10	46	1		1				4.60	.10	46.00
7	13	40	2		2				3.08	.15	20.00
7A	7	26	1		1				3.71	.14	26.00
9	50	166	6	2	2		1	1	3.32	.12	27.67
10	6	16	3		3				2.67	.50	5.33
11	4	5	1				1		1.25	.25	5.00
12	26	111	6		6				4.26	.23	18.50
14	56	292	17		17				5.21	.30	17.18
15	5	14	0						2.80	0	
15A	1	6	0						6.00	0	
17A	23	81	6		6				3.52	.26	13.50
21	23	91	2		2				3.96	.09	45.50
21A	19	72	2		2				3.79	.11	36.00
26	64	344	17	1	16				5.38	.27	20.24
Total	298[b]	1381	65	3	59	0	2	1	4.63	.22	21.25

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 11. Group I - first mailing. Reported information and means for both seasons combined.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	36	204	2		1	1			5.56	.06	100.00
1	13	56	5		3	2			4.31	.38	11.20
2	4	16	0						4.00	0	
2A	15	84	3		3				5.60	.20	28.00
3	26	253	10		5	4	1		9.73	.38	25.30
4	29	154	5		5				5.31	.17	30.80
5	39	206	5		5				5.28	.13	41.20
6A	13	88	4		4				6.77	.31	22.00
7	56	266	10		10				4.75	.18	26.60
7A	50	285	7		7				5.70	.14	40.71
9	245	1374	44	2	40		1	1	5.61	.18	31.23
10	38	161	7		7				4.24	.18	23.00
11	13	44	2		1		1		3.38	.15	22.00
12	66	301	12		12				4.56	.18	25.08
14	107	523	20		20				4.89	.19	26.15
15	31	127	3		3				4.10	.10	42.33
15A	13	54	1		1				4.15	.08	54.00
17	32	141	8		8				4.41	.25	17.63
17A	87	391	20		20				4.49	.23	19.55
19A	25	136	8		8				5.44	.32	17.00
21	97	441	13		11	1	1		4.55	.13	33.92
21A	62	292	12		12				4.71	.19	24.33
26	64	344	17	1	16				5.38	.27	20.24
Total	870[b]	5941	218	3	202	8	4	1	6.82	.25	27.25

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

the only legal age-sex class for these seasons).

Group I - Second Mailing

Tables 12 to 14 present reported information and means for the early, late, and combined seasons for those licensees from group I who responded to the second mailing. An adult female was reported harvested in Game Hunting Area 9 during the early season (Table 12) when adult males were the only legal age-sex class for that season.

Group II - First Mailing

Tables 15 to 17 present reported information and means for the early, late, and combined seasons for those licensees from group II who responded to the first mailing.

Group II - Second Mailing

Tables 18 to 20 present reported information and means for the early, late, and combined seasons for those licensees from group II who responded to the second mailing.

Comparison of Groups I and II

(a) Season Selection

The proportion of hunters who chose to hunt during the late season (Table 21) was not different between mailings for group I (two-tailed test; $z = 1.08$; $n_1 = 1025$, $n_2 = 231$; $P > 0.05$) or group II (two-tailed test; $z = 0.62$; $n_1 = 218$, $n_2 = 48$; $P > 0.05$). The total number of hunters used to calculate this proportion was arrived at by the addition of the number hunting during the early season and the number hunting during the late season (eg., 298 + 727 = 1025 for Group I - First Mailing). This proportion could be considered synonymous to the proportion of hunts which occurred during the late season. When data from both mailings were combined, the proportion of winter hunters was different between groups (two-tailed test; $z = -11.16$; $n_1 = 1256$, $n_2 = 266$; $P < 0.002$).

Table 12. Group I - second mailing. Reported information and means for the early season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	21	131	4		4				6.24	.19	32.75
1	4	18	2		2				4.50	.50	9.00
2	3	36	0						12.00	0	
2A	2	19	0						9.50	0	
3	7	39	2		1	1			5.57	.29	19.50
4	5	20	3		3				4.00	.60	6.67
5	9	66	1		1				7.33	.11	66.00
6A	2	7	0						3.50	0	
7	5	29	0						5.80	0	
7A	12	67	2		2				5.58	.17	33.50
9	50	327	6		5	1			6.54	.12	54.50
10	3	10	1		1				3.33	.33	10.00
11	3	18	0						6.00	0	
12	13	77	4	1	3				5.92	.31	19.25
14	18	81	3		3				4.50	.17	27.00
15	9	31	2		2				3.44	.22	15.50
17	9	66	2		2				7.33	.22	33.00
17A	11	43	0						3.91	0	
19A	3	21	0						7.00	0	
21	17	107	3		3				6.29	.18	35.67
21A	9	45	1		1				5.00	.11	45.00
Total	172[b]	1258	36	1	33	2	0	0	7.31	.21	34.94

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 13. Group I - second mailing. Reported information and means for the late season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	4	20	1		1				5.00	.25	20.00
2	4	23	1			1			5.75	.25	23.00
2A	1	2	0						2.00	0	
3	2	11	0						5.50	0	
4	2	11	1		1				5.50	.50	11.00
5	1	3	0						3.00	0	
7	2	7	0						3.50	0	
7A	3	8	0						2.67	0	
9	8	38	2		1	1			4.75	.25	19.00
10	1	3	0						3.00	0	
11	1	1	0						1.00	0	
12	8	27	0						3.38	0	
14	8	28	2		2				3.50	.25	14.00
15	1	5	1		1				5.00	1.00	5.00
17A	4	19	0						4.75	0	
21	5	9	1		1				1.80	.20	9.00
21A	5	13	1		1				2.60	.20	13.00
26	9	36	3		3				4.00	.33	12.00
Total	59[b]	264	13	0	11	2	0	0	4.47	.22	20.31

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 14. Group I - second mailing. Reported information and means for both seasons combined.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	25	151	5		5				6.04	.20	30.20
1	4	18	2		2				4.50	.50	9.00
2	7	59	1			1			8.43	.14	59.00
2A	3	21	0						7.00	0	
3	9	50	2		1	1			5.56	.22	25.00
4	7	31	4		4				4.43	.57	7.75
5	10	69	1		1				6.90	.10	69.00
6A	2	7	0						3.50	0	
7	7	36	0						5.14	0	
7A	15	75	2		2				5.00	.13	37.50
9	58	365	8		6	2			6.29	.14	45.63
10	4	13	1		1				3.25	.25	13.00
11	4	19	0						4.75	0	
12	21	104	4	1	3				4.95	.19	26.00
14	26	109	5		5				4.19	.19	21.80
15	10	36	3		3				3.60	.30	12.00
17	9	66	2		2				7.33	.22	33.00
17A	15	62	0						4.13	0	
19A	3	21	0						7.00	0	
21	22	116	4		4				5.27	.18	29.00
21A	14	58	2		2				4.14	.14	29.00
26	9	36	3		3				4.00	.33	12.00
Total	226[b]	1522	49	1	44	4	0	0	6.73	.22	31.06

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 15. Group II - first mailing. Reported information and means for the early season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	5	24	0						4.80	0	
3	2	6	0						3.00	0	
5	1	5	0						5.00	0	
6A	1	5	0						5.00	0	
7	5	13	1		1				2.60	.20	13.00
7A	5	31	1		1				6.20	.20	31.00
9	11	39	2		2				3.55	.18	19.50
10	6	20	0						3.33	0	
12	4	14	2		2				3.50	.50	7.00
14	13	58	2		2				4.46	.15	29.00
15	4	25	0						6.25	0	
15A	5	14	0						2.80	0	
17	5	26	3		3				5.20	.60	8.67
17A	13	70	0						5.38	0	
19A	2	4	0						2.00	0	
21	5	24	0						4.80	0	
21A	7	64	0						9.14	0	
Total	76[b]	442	11	0	11	0	0	0	5.81	.14	40.18

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 16. Group II - first mailing. Reported information and means for the late season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	1	2	0						2.00	0	
1	1	2	1		1				2.00	1.00	2.00
2	1	6	0						6.00	0	
4	2	6	1		1				3.00	.50	6.00
5	2	6	0						3.00	0	
7	4	13	0						3.25	0	
7A	3	11	1		1				3.67	.33	11.00
9	13	52	2			2			4.00	.15	26.00
10	5	23	2		2				4.60	.40	11.50
12	19	99	1		1				5.21	.05	99.00
14	25	116	5		5				4.64	.20	23.20
15	2	4	1		1				2.00	.50	4.00
15A	1	1	0						1.00	0	
17A	12	47	1		1				3.92	.08	47.00
21	7	27	0						3.86	0	
21A	5	21	0						4.20	0	
26	52	242	10		10				4.65	.19	24.20
Total	142[b]	678	25	0	23	2	0	0	4.77	.18	27.12

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 17. Group II - first mailing. Reported information and means for both seasons combined.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	6	26	0						4.33	0	
1	1	2	1		1				2.00	1.00	2.00
2	1	6	0						6.00	0	
3	2	6	0						3.00	0	
4	2	6	1		1				3.00	.50	6.00
5	3	11	0						3.67	0	
6A	1	5	0						5.00	0	
7	9	26	1		1				2.89	.11	26.00
7A	8	42	2		2				5.25	.25	21.00
9	24	91	4		2	2			3.79	.17	22.75
10	11	43	2		2				3.91	.18	21.50
12	23	113	3		3				4.91	.13	37.67
14	38	174	7		7				4.58	.18	24.86
15	6	29	1		1				4.83	.17	29.00
15A	6	15	0						2.50	0	
17	5	26	3		3				5.20	.60	8.67
17A	25	117	1		1				4.68	.04	117.00
19A	2	4	0						2.00	0	
21	12	51	0						4.25	0	
21A	12	85	0						7.08	0	
26	52	242	10		10				4.65	.19	24.20
Total	210[b]	1120	36	0	34	2	0	0	5.33	.17	31.11

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 18. Group II - second mailing. Reported information and means for the early season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
3	1	4	1					1	4.00	1.00	4.00
7	1	2	0						2.00	0	
7A	2	6	0						3.00	0	
9	2	11	0						5.50	0	
10	1	4	0						4.00	0	
12	1	3	1		1				3.00	1.00	3.00
17	1	5	0						5.00	0	
17A	6	32	0						5.33	0	
19A	1	7	0						7.00	0	
21	4	10	2		2				2.50	.50	5.00
Total	19[b]	84	4	0	3	0	0	1	4.42	.21	21.00

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 19. Group II - second mailing. Reported information and means for the late season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	2	17	0						8.50	0	
7	1	2	0						2.00	0	
7A	1	2	1		1				2.00	1.00	2.00
9	2	9	1		1				4.50	.50	9.00
10	1	5	0						5.00	0	
12	3	19	0						6.33	0	
14	8	40	1		1				5.00	.13	40.00
17A	4	25	0						6.25	0	
21	2	8	0						4.00	0	
21A	1	4	1		1				4.00	1.00	4.00
26	5	29	0						5.80	0	
Total	29[b]	160	4	0	4	0	0	0	5.52	.14	40.00

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 20. Group II - second mailing. Reported information and means for both seasons combined.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	2	17	0						8.50	0	
3	1	4	1					1	4.00	1.00	4.00
7	2	4	0						2.00	0	
7A	3	8	1		1				2.67	.33	8.00
9	4	20	1		1				5.00	.25	20.00
10	2	9	0						4.50	0	
12	4	22	1		1				5.50	.25	22.00
14	8	40	1		1				5.00	.13	40.00
17	1	5	0						5.00	0	
17A	10	57	0						5.70	0	
19A	1	7	0						7.00	0	
21	6	18	2		2				3.00	.33	9.00
21A	1	4	1		1				4.00	1.00	4.00
26	5	29	0						5.80	0	
Total	43[b]	244	8	0	7	0	0	1	5.67	.19	30.50

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 21. Proportion of hunters who chose to hunt during the late season.

Group	Mailing		
	First	Second	First and second
I	.291	.255	.284
II	.651	.604	.643

(b) Proportion Hunting in Both Seasons

The proportion of hunters who chose to hunt during both seasons (Table 22) was greater for respondents to the first mailing of group I (two-tailed test; $z = 5.92$; $n_1 = 870$, $n_2 = 226$; $P < 0.002$). Conversely, this proportion was less for respondents to the first mailing of group II (two-tailed test; $z = -2.12$; $n_1 = 210$, $n_2 = 43$; $P < 0.05$). The proportion of hunters who hunted during both seasons was considerably greater (two-tailed test; $z = 4.06$; $n_1 = 1096$, $n_2 = 253$; $P < 0.002$) for group I than group II. These proportions were calculated using the numbers provided in Tables 9 to 20 (eg., $\hat{p} = (727 + 298 - 870) \div 870$ for Group I - First Mailing).

Table 22. Proportion of hunters who chose to hunt during both seasons.

Group	Mailing		
	First	Second	First and second
I	.178	.022	.146
II	.038	.116	.051

(c) Seasonal Distribution of Harvest

The proportion of the harvest which occurred during the late season (Table 23) was not different between mailings for group I (two-tailed test; $z = 0.46$; $n_1 = 218$, $n_2 = 49$; $P > 0.05$) or group II (two-tailed test; $z = 1.05$; $n_1 = 36$, $n_2 = 8$; $P > 0.05$). The data from both mailings were combined and the proportion of harvest from the late season was considerably greater (two-tailed test; $z = -4.75$; $n_1 = 267$, $n_2 = 44$; $P < 0.002$) for respondents from group II than group I.

Table 23. Proportion of harvest during the late season.

Group	Mailing		
	First	Second	First and second
I	.298	.265	.292
II	.694	.500	.659

(d) Geographic Distribution of Hunters (Game Hunting Area 26)

The proportion of late season hunters who hunted in Game Hunting Area 26 (Table 24) was not different between mailings for group I (two-tailed test; $z = 1.29$; $n_1 = 325$, $n_2 = 69$; $P > 0.05$) or group II (two-tailed test; $z = 1.83$; $n_1 = 155$, $n_2 = 30$; $P > 0.05$). The total number of hunters used to calculate this proportion was arrived at by the addition of the number hunting in each of the Game Hunting Areas open during the late season (eg., 8 + 3 + 1 + 1 + 5 + 10 + 13 + 7 + 50 + 6 + 4 + 26 + 56 + 5 + 1 + 23 + 23 + 19 + 64 = 325 for Group I - First Mailing). When data from both mailings were lumped together, a substantially greater proportion (two-tailed test; $z = 3.30$; $n_1 = 394$, $n_2 = 185$; $P < 0.002$) of the late season hunters hunted in Game Hunting Area 26 for group II than group I.

Table 24. Proportion of late season hunters who hunted in Game Hunting Area 26.

Group	Mailing		
	First	Second	First and second
I	.197	.130	.185
II	.335	.167	.308

(e) Mean Number of Days Hunted

The mean number of days spent hunting was greater for respondents to the first mailing for some season/group combinations and less for other combinations (Table 25). Respondents from group I averaged more days hunting than respondents from group II during the early season and both seasons while respondents from group II averaged more days hunting during the late season.

Table 25. Mean number of days spent hunting.

Season	Group	Mailing		
		First	Second	First and second
Early	I	6.27	7.31	6.47
	II	5.81	4.42	5.49
Late	I	4.63	4.41	4.61
	II	4.77	5.52	4.90
Both	I	6.82	6.73	6.81
	II	5.33	5.67	5.39

Non-respondents

Tables 26 to 28 present reported information and means for the early, late, and combined seasons for the sample of non-respondents. The reported harvest was 23 moose for the early season; however, one of these moose was either a cow or a calf (the hunter was unsure which animal had received his tag) and is indicated as an unknown age-sex in Table 26.

Comparison of First Mailing, Second Mailing, and Non-respondents

The proportion of hunters who chose to hunt during the late season (Table 29) was not different between mailings (two-tailed test; $z = 1.22$; $n_1 = 1243$, $n_2 = 279$; $P > 0.05$). This proportion was greater (two-tailed test; $z = -1.97$; $n_1 = 1522$, $n_2 = 253$; $P < 0.05$) for non-respondents than the combination of both mailings.

Table 29. Some characteristics of respondents to the first and second mailings and non-respondents.

Characteristic	Season	First mailing	Second mailing	First and second mailing	Non-respondents
Proportion of hunters who chose to hunt during the late season	N/A	.354	.315	.347	.411
Proportion of hunters who hunted during both seasons	N/A	.151	.037	.128	.172
Proportion of harvest from the late season	N/A	.354	.298	.344	.207
Proportion of late season hunters who hunted in G.H.A. 26	N/A	.242	.141	.225	.327
Mean number of days spent hunting	Early	6.23	7.03	6.38	5.55
	Late	4.68	4.82	4.70	3.64
	Both	6.54	6.57	6.54	5.55

Table 26. Non-respondents. Reported information and means for the early season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	5	47	0						9.40	0	
1	2	5	2	1	1				2.50	1.00	2.50
2A	2	7	0						3.50	0	
3	5	21	2		2				4.20	.40	10.50
4	2	8	0						4.00	0	
5	11	54	0						4.91	0	
6A	3	13	0						4.33	0	
7	8	58	0						7.25	0	
7A	5	29	3		3				5.80	.60	9.67
9	30	192	4		4				6.40	.13	48.00
10	14	47	2		2				3.36	.14	23.50
11	1	3	0						3.00	0	
12	6	22	0						3.67	0	
14	17	71	4		4				4.18	.24	17.75
15	6	19	2		2				3.17	.33	9.50
15A	4	20	1		1				5.00	.25	20.00
17	2	8	0						4.00	0	
17A	4	26	0						6.50	0	
19A	10	31	1		1				3.10	.10	31.00
21	6	36	2		2				6.00	.33	18.00
21A	6	21	0						3.50	0	
Total	133[b]	738	23	1	22	0	0	0	5.55	.17	32.09

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 27. Non-respondents. Reported information and means for the late season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	2	7	0						3.50	0	
4	2	7	0						3.50	0	
5	2	5	0						2.50	0	
7	3	10	0						3.33	0	
7A	2	5	0						2.50	0	
9	12	38	2		1		1		3.17	.17	19.00
10	4	12	0						3.00	0	
11	1	2	0						2.00	0	
12	4	21	0						5.25	0	
14	18	75	2		2				4.17	.11	37.50
15	3	7	0						2.33	0	
15A	2	2	0						1.00	0	
17A	3	8	1		1				2.67	.33	8.00
21	7	19	0						2.71	0	
21A	5	21	0						4.20	0	
26	34	121	1		1				3.56	.03	121.00
Total	99[b]	360	6	0	5	0	1	0	3.64	.06	60.00

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 28. Non-respondents. Reported information and means for both seasons combined.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	7	54	0						7.71	0	
1	2	5	2	1	1				2.50	1.00	2.50
2A	2	7	0						3.50	0	
3	5	21	2		2				4.20	.40	10.50
4	4	15	0						3.75	0	
5	13	59	0						4.54	0	
6A	3	13	0						4.33	0	
7	11	68	0						6.18	0	
7A	7	34	3		3				4.86	.43	11.33
9	42	230	6		5		1		5.48	.14	38.33
10	18	59	2		2				3.28	.11	29.50
11	2	5	0						2.50	0	
12	10	43	0						4.30	0	
14	35	146	6		6				4.17	.17	24.33
15	9	26	2		2				2.89	.22	13.00
15A	6	22	1		1				3.67	.17	22.00
17	2	8	0						4.00	0	
17A	7	34	1		1				4.86	.14	34.00
19A	10	31	1		1				3.10	.10	31.00
21	13	55	2		2				4.23	.15	27.50
21A	11	42	0						3.82	0	
26	34	121	1		1				3.56	.03	121.00
Total	198[b]	1098	29	1	27	0	1	0	5.55	.15	37.86

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting area.

It was hypothesized that the proportion of hunters who hunted during both seasons would decrease in magnitude from respondents to the first mailing to respondents to the second mailing to non-respondents, hence a one-tailed test was utilized. This proportion decreased (one-tailed test; $z = 4.99$; $n_1 = 1080$, $n_2 = 269$; $P < 0.002$) from respondents to the first mailing to respondents to the second mailing. The anticipated decrease did not occur when this proportion was compared for respondents to the second mailing (one-tailed test; $z = -4.92$; $n_1 = 269$, $n_2 = 198$; $P > 0.50$) or respondents to the first mailing (one-tailed test; $z = -0.74$; $n_1 = 1080$, $n_2 = 198$; $P > 0.50$) to that for non-respondents. The proportion of hunters who hunted during both seasons was not greater (one-tailed test; $z = -1.68$; $n_1 = 1349$, $n_2 = 198$; $P > 0.50$) for respondents to both mailings than non-respondents.

The proportion of harvest from the late season did not differ (two-tailed test; $z = 0.81$; $n_1 = 254$, $n_2 = 57$; $P > 0.05$) between respondents to the first mailing and respondents to the second mailing. This proportion did not differ (two-tailed test; $z = 1.50$; $n_1 = 311$, $n_2 = 29$; $P > 0.05$) between respondents to both mailings and non-respondents.

The proportion of late season hunters who hunted in Game Hunting Area 26 was greater (two-tailed test; $z = 2.18$; $n_1 = 480$, $n_2 = 99$; $P < 0.05$) for respondents to the first mailing than respondents to the second mailing. The proportion of late season hunters who hunted in Game Hunting Area 26 was greater for non-respondents than respondents to the second mailing (two-tailed test; $z = 3.11$; $n_1 = 104$, $n_2 = 99$; $P < 0.002$) but not different than respondents to the first mailing (two-tailed test; $z = 1.80$; $n_1 = 104$, $n_2 = 480$; $P > 0.05$). The proportion was greater for non-respondents (two-tailed test; $z = 2.25$; $n_1 = 104$, $n_2 = 579$; $P < 0.05$) than for respondents from both mailings combined.

The respondents to the second mailing reported spending more days hunting than respondents to the first mailing for the early, late, and both seasons combined. Respondents to both mailings combined reported hunting approximately 1 day more than non-respondents for the early, late, and both seasons combined.

Comparison of Groups I, II, Non-respondents, and Simulated Group - Statistics Integral to Harvest Estimation

(a) Proportion of Respondents Hunting

The proportion of respondents who hunted (Table 30) was greater for respondents to the first mailing than the second mailing for both group I (one-tailed test; $z = 3.01$; $n_1 = 956$, $n_2 = 267$; $P < 0.002$) and group II (one-tailed test; $z = 2.66$; $n_1 = 227$, $n_2 = 53$; $P < 0.002$). When data from both mailings were combined, the proportion did not differ between groups (two-tailed test; $z = 0.53$; $n_1 = 1223$, $n_2 = 280$; $P > 0.05$) and the combination of data resulted in an estimate that 89.8% of the respondents hunted.

Table 30. Proportion of respondents who hunted.

Group	Mailing		First and second mailings
	First	Second	
I	.910	.846	.896[b]
II	.925	.811	.907[b]
I&II			.898[b]
NR[a]	N/A	N/A	.912
SIM[a]	N/A	N/A	.914

[a]NR represents the non-respondent group, SIM represents the simulated group.
[b]Proportion represents that for both mailings combined.

The proportion of non-respondents who hunted was not less than that of respondents for the simulated group (one-tailed test; $z = -0.09$; $n_1 = 217$, $n_2 = 1203$; $P > 0.05$) or the combination of groups I and II (one-tailed test; $z = 0.66$; $n_1 = 217$, $n_2 = 1502$; $P > 0.05$). The proportion of respondents who hunted was not greater (one-tailed test; $z = -1.43$; $n_1 = 1502$, $n_2 = 1203$; $P < 0.08$) for the combination of groups I and II than the simulated group. This later comparison is not a particularly meaningful

comparison because the 2 proportions are not mutually exclusive (i.e., the proportion for the combination of groups I and II include the majority of the data utilized in calculating the proportion for the simulated group).

(b) Success Rate

The success rate of those licensees who hunted (proportion of hunters who tagged a moose) is detailed in Table 31. The success rate of hunters from the first mailing was not greater than hunters from the second mailing for group I (one-tailed test; $z = 1.05$; $n_1 = 870$, $n_2 = 226$; $P > 0.05$) or group II (one-tailed test; $z = -0.23$; $n_1 = 210$, $n_2 = 43$; $P > 0.50$). When data from both groups were combined, the success rate of hunters from the first mailing was not greater (one-tailed test; $z = 0.81$; $n_1 = 1080$, $n_2 = 269$; $P > 0.05$) than that of hunters from the second mailing. The success rate of hunters from group I (24.4%) was greater (one-tailed test; $z = 2.37$; $n_1 = 1096$, $n_2 = 253$; $P < 0.02$) than that of hunters from group II (18.1%).

Table 31. Success rate of licensees who hunted.

Group	Mailing		First and second mailings
	First	Second	
I	.251	.217	.244[b]
II	.171	.186	.181[b]
I&II	.235	.212	.231[b]
NR[a]	N/A	N/A	.146
SIM[a]	N/A	N/A	.240

[a]NR represents the non-respondent group, SIM represents the simulated group.
[b]Proportion represents that for both mailings combined.

The success rate for both groups and mailings combined (23.1%) was greater (one-tailed test; $z = 2.67$; $n_1 = 1349$, $n_2 = 198$; $P < 0.01$) than the success rate for the group of non-respondents (14.6%). The success rate for the simulated group was not greater than that of

respondents from groups I and II (one-tailed test; $z = 0.55$; $n_1 = 1100$, $n_2 = 1349$; $p > 0.05$). Again, this comparison is not a particularly good comparison because the 2 proportions are not mutually exclusive.

(c) Kill Rate

The kill rate incorporates both the success rate and the proportion of licensees who hunt to yield a proportion of licensees who are successful in tagging a moose (Table 32). This rate can be used to estimate harvest per unit area (per Game Hunting Area or larger). The kill rate for respondents to the first mailing was not greater than that for respondents to the second mailing for group I (one-tailed test; $z = 1.56$; $n_1 = 956$, $n_2 = 267$; $P = 0.06$) or group II (one-tailed test; $z = 0.14$; $n_1 = 227$, $n_2 = 53$; $P > 0.05$). The kill rate for respondents to the first mailing was not greater (one-tailed test; $z = 1.43$; $n_1 = 1183$, $n_2 = 320$; $P = 0.08$) than that for respondents to the second mailing when mailings from both groups were combined. The kill rate for respondents from group I (21.8%) was greater (one-tailed test; $z = 2.28$; $n_1 = 1223$, $n_2 = 280$; $P < 0.02$) than for respondents from group II (15.7%) when both mailings were combined.

The kill rate for both mailings and both groups combined (20.7%) was greater (one-tailed test; $z = 2.53$; $n_1 = 1503$, $n_2 = 217$; $P < 0.01$) than that recorded for non-respondents (13.4%). The kill rate for the simulated group was almost identical to that recorded for the respondents to the first mailing (both groups). This similarity is not surprising given that the data used to calculate the kill rates was almost identical for both groups. The kill rate of the simulated group was not greater (one-tailed test; $z = 0.79$; $n_1 = 1203$, $n_2 = 1503$; $P > 0.05$) than that of the combination of respondents from groups I and II. These 2 proportions (simulated group and combination of groups I and II) are not mutually exclusive groups.

Table 32. Kill rate by group and mailing.

Group	Mailing		First and second mailings
	First	Second	
I	.228	.184	.218[b]
II	.159	.151	.157[b]
I&II	.215	.178	.207[b]
NR[a]	N/A	N/A	.134
SIM[a]	N/A	N/A	.219

[a]NR represents the non-respondent group, SIM represents the simulated group.
[b]Proportion represents that for both mailings combined.

Harvest Estimation

(a) All Game Hunting Areas Combined

Estimates of total harvest adjusted for non-response bias and the figures necessary to calculation of each of these harvest estimates are presented in Table 33. The total harvest of moose during the early season was estimated at 664 ± 95. Total harvest estimates were 287 ± 55 for the late season and 950 ± 106 for both seasons combined.

Harvest estimates adjusted for non-response bias and for the simulated group are presented for each of the age/sex classes in Table 34. Total harvest was calculated using a total of 5374 hunters for the non-response bias adjusted estimates (the final figure for total hunters) and 5354 hunters for the simulated estimates (the figure available at 30 April 1987 when the estimate was made). The difference apparent between estimates for some age/sex classes are partially a function of small samples as even 1 additional animal can influence some estimates significantly (eg., 1 additional reported animal will increase an estimate for the simulated group by 4).

Table 33. Total harvest estimates incorporating data from respondents to the first and second mailing (both groups combined) and non-respondents. Information necessary to estimation for the early, late, and both seasons combined is included.

Season	Number of licenses sold[a]	Number of hunters sent questionnaires	Respondents		Non-respondents					Estimated harvest from sample[c]	Total estimated harvest (± 95% confidence limits)[d]
			Number	Total harvest	Number	Number sampled	Number from which data obtained	Total harvest	Estimated harvest[b]		
Early	5374	2551	1503	204	1048	250	217	23	111	315	664 ± 95
Late	5374	2551	1503	107	1048	250	217	6	29	136	287 ± 55
Both	5374	2551	1503	311	1048	250	217	29	140	451	950 ± 106

[a]Based on final figure for licenses purchased (as of 14 December 1987).
[b]Estimate calculated by multiplying total harvest by (number of non-respondents in sample (1048) divided by number of non-respondents from which data was obtained (217)).
[c]Estimated harvest from sample of hunters sent questionnaires (2551) calculated by addition of harvest from respondents and estimated harvest from non-respondents.
[d]Total estimated harvest calculated by multiplying estimated harvest from sample by (number of licenses sold (5374) divided by number of hunters sent questionnaires (2551)). Calculation of confidence limits via method of Hansen and Hurwitz (1946).

Table 34. Harvest estimates for each age/sex class and total harvest incorporating data from respondents and non-respondents. Harvest estimates from the simulated group are included for comparative purposes.

Season	Group	Harvest (± 95% confidence limits)[a]					
		Total	Unknown	Adult male	Adult female	Immature male	Immature female
Early	ALL[b]	664(95)	12(19)	624(93)	21(9)	4(4)	2(3)
	SIM[b]	765(102)	0	725(100)	36(25)	4(9)	0
Late	ALL	286(55)	6(5)	255(51)	8(6)	14(19)	2(3)
	SIM	409(74)	13(15)	374(72)	13(15)	4(9)	4(9)
Both	ALL	950(106)	19(20)	879(103)	29(11)	19(20)	4(4)
	SIM	1175(124)	13(15)	1099(121)	49(29)	9(12)	4(9)

[a]Confidence limits for ALL group via method of Hansen and Hurwitz (1946); confidence limits for SIM group calculated as in Hummelt (1986).
[b]ALL represents group which includes data from non-respondents, SIM represents simulated group.

The estimate adjusted for non-response bias represents the best possible estimate of harvest, therefore the standard method overestimated harvest during the early season by 101 moose or 15.2%. The standard method overestimated harvest during the late season by 43.0% (123 moose) and harvest from both seasons by 23.7% (225 moose). Use of the kill rate for both mailings combined as an estimate for non-respondents results in a total harvest estimate of 1112 moose (0.207 x 5374). Use of the kill rate from the second mailing as an estimate for non-respondents results in an estimate of 1049 moose ((0.215 x 0.464 + 0.178 x 0.536) x 5374).

(b) Application of a Modified Wave Method for the Control of Non-response

The harvest estimates and the figures necessary to calculation of these estimates via the modified wave method are presented in Table 35. The harvest estimates made with the modified wave method overestimated those made with data from non-respondents by 2.1% for the

Table 35. Harvest estimates calculated with the modified wave method. Estimates for total early season harvest, total late season harvest, and total harvest for both seasons combined.

Season	Wave I		Waves I & II		Kill rate = a + b X Number of questionnaires (y = a + bx)	Estimated Kill rate at 100% return (x = 2551)	Harvest estimate[a]
	Number of questionnaires	Kill rate	Number of questionnaires	Kill rate			
Early	1183	.13863	1503	.13573	y = .14935 - .0000090625x	.1262	678
Late	1183	.07608	1503	.07119	y = .09416 - .00001528x	.0552	297
Both	1183	.21471	1503	.20692	y = .243506 - .0000243x	.1815	975

[a]Harvest estimate calculated via multiplying estimated kill rate at 100% return by total number of hunters (5374).

early season, 3.5% for the late season, and 2.6% for both seasons.

(c) Game Hunting Area 26

The estimates of harvest from G.H.A. 26 (Table 36) were made using a $\hat{p}$ calculated by dividing the number of moose killed in G.H.A. 26 by the total licensees (kill rate for moose in G.H.A. 26). The estimate should have been for the late season only because G.H.A. 26 was not open during the early season; however, the estimate calculated for the simulated group was based upon raw data which included 1 moose harvested during the early season. The harvest estimate for G.H.A. 26 (both seasons) which resulted from simulation of the normal procedure overestimated harvest (both respondents and non-respondents) by 64.4%.

Table 36. Estimates for total harvest for the simulated group and for the group incorporating data from respondents and non-respondents.

Season[a]	Group	Harvest (± 95% confidence limits)[b]
Late	SIM[c]	116(39)
	ALL[c]	73(25)
Both	SIM	120(39)
	ALL	73(25)

[a]Estimates for late season and both seasons included because the simulated group provided estimates of moose being killed during the early season (which was not open for G.H.A. 26).
[b]Harvest estimates calculated using 5354 licenses for the SIM group and 5374 licenses for the ALL group. Confidence limits for ALL group via method of Hansen and Hurwitz (1946); confidence limits for SIM group calculated as in Hummelt (1986).
[c]All represents group which includes data from non-respondents, SIM represents simulated group.

The kill rate from G.H.A. 26 (number of moose killed in G.H.A. 26 per total number of licensees) for non-respondents (Table 37) was less than that for respondents to the first mailing (one-tailed test; $z = -1.76$; $n_1 = 217$, $n_2 = 1183$; $P = 0.04$) but not different at $P = 0.05$ for respondents to both mailings (one-tailed test; $z = -1.59$; $n_1 = 217$, $n_2 = 1503$; $P = 0.06$).

The proportion of the total harvest which originated from G.H.A. 26 was not different between non-respondents and respondents to the first mailing (two-tailed test; $z = -1.23$; $n_1 = 29$, $n_2 = 254$; $P > 0.22$) or respondents to both mailings (two-tailed test; $z = -1.11$; $n_1 = 29$, $n_2 = 311$; $P < 0.27$). The proportion of the winter harvest which originated from G.H.A. 26 was not different between non-respondents and respondents to the first mailing (two-tailed test; $z = -0.70$; $n_1 = 6$, $n_2 = 90$; $P > 0.48$) or respondents to both mailings (two-tailed test; $z = -0.61$; $n_1 = 6$, $n_2 = 107$; $P > 0.54$). The proportion of hunters (cumulative hunters for all G.H.A.'s) who hunted in Game Hunting Area 26 was greater (two-tailed test; $z = -2.66$; $n_1 = 1161$, $n_2 = 253$; $P < 0.01$) for non-respondents (13.5%) than respondents to the first mailing (8.2%). The success rate of respondents to the first mailing (23.3%) was greater (one-tailed test; $z = 2.68$; $n_1 = 116$, $n_2 = 34$; $P < 0.005$) than that of non-respondents (2.9%).

Table 37. Comparison of respondents and non-respondents relative to harvest statistics for G.H.A. 26.

Statistic	Respondents		Non-respondents
	First mailing	First and second mailing	
Number of moose killed in G.H.A. 26 / Number of licensees (Kill rate)	.0228	.0200	.0046(1/217)
Number of moose killed in G.H.A. 26 / Number of moose killed	.1063	.0965	.0345(1/29)
Number of moose killed in G.H.A. 26 / Number of moose killed during late season	.3000	.2804	.1667(1/6)

Application of the Wave Method to the Control of Incomplete Sampling

(a) Application of the Method

The substantial differences between groups I and II (Tables 21-24, 31, 32) indicate that incomplete sampling could seriously influence estimates. The wave method was applied to data from groups I and II in an attempt to assess the usefulness of this method for controlling the impact of incomplete sampling (Table 38).

The proportion of the total harvest from the late season increased with an increase in the proportion of stubs sampled (group I to groups I and II) and was estimated at 35.852% at complete sampling of 5374 license purchasers (stubs). The kill rate declined with an increase in the proportion of stubs sampled and was estimated at 20.374% at complete sampling. It is important to note that the linear relationships for both of these statistics were calculated from 2 groups with similar response rates (59.3% for group I and 57.4% for group II). An attempt to use this method with waves with substantially different response rates would seriously distort any true relationships which may exist (the assumption inherent to this method is that non-response bias is consistent between waves).

Two other points are important relative to the use of this method. The estimate which results at 100% sampling intensity may be a biased estimate dependent upon the statistic in question. Such an estimate can only be considered and utilized as an index under these circumstances. Kill rate could only be used as an index because the kill rate of respondents and non-respondents is different (Table 32). The proportion of harvest from the late season was not different between groups I and II and non-respondents at the standard P value of 0.05. This result would allow treatment of the estimate of the proportion of harvest from the late season as an unbiased estimate because no statistically significant difference was found to exist between respondents and non-respondents. It is critical to recognize that the sample size was small for harvest by non-respondents ($n = 29$) and the alpha level low ($P = 0.13$) given the small sample size, hence it is quite possible that a real difference does exist. Under these circumstances, the treatment of the proportion of harvest from the late

Table 38. Application of the wave method to control the impact of incomplete sampling. Method applied to the seasonal distribution of harvest and the kill rate.

Statistic	Group I		Groups I & II		Proportion = a + b X Number of stubs sampled	Estimated proportion at complete sampling (5374 stubs)
	Number of stubs sampled	Proportion	Number of stubs sampled	Proportion		
Proportion of total harvest from late season	4126	.29213	5102	.34405	y = .0726236 + .0000532x	.35852
Kill rate	4126	.21832	5102	.20692	y = .2665119 - .00001168x	.20374

season as an unbiased estimate should be made with caution.

The second point important to use of this method is that it assumes that the stubs which are not sampled are those which were received too late to be sampled. A total of 5102 stubs (94.9% of the total stubs) comprised the sample for groups I and II. The final figure for the number of licenses purchased was 5374 licenses (D. Tuck, Manitoba Department of Natural Resources, pers. commun.) of which 140 or 2.6% of total stubs were unaccounted for. It is not possible to determine when these stubs were received by Wildlife and Fisheries Licensing; however, if the stubs were received after stubs from groups I and II had been forwarded to the Wildlife Branch, the assumption would be correct. If the stubs were received prior to that time and were lost at Wildlife and Fisheries Licensing, during the transfer of stubs to the Wildlife Branch or within the Wildlife Branch, then the stubs should have been included in groups I and/or II and the assumption is incorrect. This last possibility is also important in that if it occurred, it is quite possible that a block of stubs lost during this period would contain licensees from a discrete geographic area (i.e., not a random distribution of licensees). This circumstance could adversely influence estimates on a Game Hunting Area basis.

(b) Testing the Method

Tables 39 to 41 present reported information and means for the early, late, and combined seasons for those licensees from group III who responded to either of the 2 mailings. Statistics for those licensees from group III who responded to either of the mailings are presented in Table 42.

The response rate to 2 mailings for group III was similar to that for the combination of groups I and II (statistics presented in Table 42 can be compared to statistics in Tables 21-25 and 30-32 for groups I and II and Table 37 for groups I and II combined). The kill rate for group III was not less than that for group II (one-tailed test; $z = 0.12$; $n_1 = 55$, $n_2 = 280$; $P > 0.50$) or group I (one-tailed test; $z = -0.96$; $n_1 = 55$, $n_2 = 1223$; $P < 0.17$). This lack of difference quite likely results from the small sample size for group III. Other statistics were not compared between groups because of the small sample size.

Table 39. Group III. Reported information and means for the early season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	1	3	0						3.00	0	
3	1	12	0						12.00	0	
5	1	3	0						3.00	0	
9	4	17	0						4.25	0	
10	1	5	0						5.00	0	
12	1	5	0						5.00	0	
14	2	8	0						4.00	0	
15	2	6	0						3.00	0	
17	3	18	0						6.00	0	
17A	5	16	1		1				3.20	.20	16.00
21	4	19	0						4.75	0	
21A	2	8	0						4.00	0	
Total	27	120	1	0	1	0	0	0	4.44	.04	120.00

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 40. Group III. Reported information and means for the late season.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	1	5	0						5.00	0	
9	2	10	2		1		1		5.00	1.00	5.00
12	2	10	0						5.00	0	
14	3	15	1		1				5.00	.33	15.00
15	2	7	2		2				3.50	1.00	3.50
17A	4	21	2		2				5.25	.50	10.50
21	1	6	0						6.00	0	
21A	3	9	0						3.00	0	
26	10	57	1		1				5.70	.10	57.00
Total	28	140	8	0	7	0	1	0	5.00	.29	17.50

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 41. Group III. Reported information and means for both seasons.

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	2	8	0						4.00	0	
3	1	12	0						12.00	0	
5	1	3	0						3.00	0	
9	6	27	2		1		1		4.50	.33	13.50
10	1	5	0						5.00	0	
12	3	15	0						5.00	0	
14	5	23	1		1				4.60	.20	23.00
15	4	13	2		2				3.25	.50	6.50
17	3	18	0						6.00	0	
17A	9	37	3		3				4.11	.33	12.33
21	5	25	0						5.00	0	
21A	5	17	0						3.40	0	
26	10	57	1		1				5.70	.10	57.00
Total	51	260	9	0	8	0	1	0	5.10	.18	28.89

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

The equation which relates the proportion of harvest from the late season to the number of stubs sampled predicts that the proportion should increase as more stubs are sampled (i.e,. from group II to group III). The proportion did increase from group II to group III but the difference was not statistically significant at the low sample sizes involved (one-tailed test; $z = 1.37$; $n_1 = 9$, $n_2 = 44$; $P < 0.09$). The proportion of harvest from the late season for group III was greater (one-

Table 42. Several important statistics for respondents from group III.

Statistic	Value
Response rate	.561
Proportion of hunters who chose to hunt during the late season	.509
Proportion of hunters who hunted during both seasons	.078
Proportion of harvest from the late season	.889
Proportion of late season hunters who hunted in G.H.A. 26	.357
Mean number of days spent hunting	Early 4.44 Late 5.00 Both 5.10
Proportion of respondents who hunted	.927
Success rate	.176
Kill rate	.164
$\frac{\text{Number of moose killed in G.H.A. 26}}{\text{Number of licensees}}$	.018
$\frac{\text{Number of moose killed in G.H.A. 26}}{\text{Number of moose killed}}$	.111
$\frac{\text{Number of moose killed in G.H.A. 26}}{\text{Number of moose killed during late season}}$	.125

tailed test; $z = 3.36$; $n_1 = 9$, $n_2 = 311$; $P < 0.001$) than that for groups I and II combined.

The equation predicts that the proportion of harvest from the late season should be 34.93% when data from group III is included (5200 stubs) but this proportion was actually 35.94%. The true proportion (35.94%) was similar to the proportion estimated at 100% sampling (35.85%) and was greater than the proportion for groups I and II (34.41%) as predicted (i.e., the proportion did increase with an increase in the number of stubs sampled). The discrepancy (approximately 1%) between predicted and result may relate in part from the stubs from group III being treated as if they were received directly after those from groups I and II. This may not have been the case (i.e., these stubs may have been received by Wildlife and Fisheries Licensing after the majority of the stubs which are unaccounted for).

The equation which relates the kill rate to the number of stubs sampled predicts that kill rate should decrease as more stubs are sampled. The kill rate was slightly greater for group III than for group II which is opposite to the prediction and did not support acceptance of the alternate hypothesis that kill rate was less for group III (one-tailed test; $z = -0.12$; $n_1 = 280$, $n_2 = 55$; $P > 0.50$). The kill rate for groups I and II combined was not greater (one-tailed test; $z = 0.78$; $n_1 = 1503$, $n_2 = 55$; $P < 0.22$) than the kill rate for group III.

The equation predicts that the kill rate should be 20.58% when data from group III is included. The proportion was actually 20.54% which is slightly under that predicted by the equation. This kill rate was less than the kill rate for groups I and II (20.69%) as was predicted by the equation (i.e., the kill rate did decrease with an increase in the number of stubs sampled).

The response rate to 1 mailing was only 19.2% for group IV. All 5 of the respondents hunted with 2 licensees hunting during the early season. Three licensees hunted in a total of 4 Game Hunting Areas during the late season. None of the 5 respondents were successful.

A Further Estimate of Harvest Adjusted for Incomplete Sampling

The kill rate generated from the 5102 license stubs sampled was

assumed to apply to the 272 stubs not sampled (received late or not accounted for) to estimate total harvest. Kill rates for groups I, II, and III resulted from similar response rates and are therefore comparable. Although the kill rate of group III was less than that of groups I and II combined, as predicted, this difference was not statistically significant ($P < 0.22$). The lack of a statistically significant difference is not surprising given the small sample size for group III ($n = 55$). The overestimation of kill rate (20.58% as compared to 20.54%) and the result that the equation accurately predicted a decrease in kill rate with greater sampling (addition of group III) are evidence in support of the use of the equation to adjust for incomplete sampling. The total harvest estimate was adjusted given assumptions that the equation accurately predicted the change in kill rate to 100% sampling (i.e., the hypothesis that the kill rate was lower for the later 5.1% of the license stubs was a correct hypothesis) and that the unaccounted for stubs were received after those which comprised the first 2 groups.

The kill rate estimate of .176815 (for the 94.9% of license stubs sampled) had already been adjusted for non-response bias. The equation relating kill rate to the number of stubs sampled is:

$$y = .2665119 - .00001168x$$

where y is estimated kill rate and
x is number of stubs sampled.

The kill rate is estimated at .20692 at a 94.9% sampling rate (5102 stubs) and .20374 at a sampling rate of 100% (5374 stubs). The estimated rate at 100% sampling is .9846 that of the rate at 94.9% sampling (.20374 ÷ .20692). This proportion was applied to the rate of .176815 (adjusted for non-response bias) to result in an estimated kill rate of .174098 (.176815 X .9846) which has been adjusted for both non-response bias and incomplete sampling. The application of this kill rate to the total number of license stubs (.174098 X 5374) results in a total harvest estimate of 936 moose.

The estimated <u>proportional</u> change in kill rate from incomplete sampling (94.9%) to complete sampling (100%) is based upon an equation developed with kill rates calculated from response rates of 59.3% (group I) and 57.4% (group II). This equation was applied to a kill rate which was corrected for non-response bias (i.e., adjusted to estimate kill rate at

100% response). The application of the proportion .9846 to the kill rate of .176815 assumes that the proportion .9846 estimates accurately the proportion which would result if the equation had been developed from kill rates based on a 100% response rate. The validity of such an assumption is unknown; however, it might be expected that such an equation relating kill rate to number of stubs sampled (based on kill rates estimated at 100% response) would have a smaller intercept and slope (to maintain a consistent rate of non-response bias) then the equation developed from incomplete response. The proportional change from 94.9% to complete sampling results from the interaction between slope and intercept therefore this proportion could be the same in both cases.

Incompleteness and Conflicting Information in Returned Hunter Questionnaires

A large number of rules for handling missing or confusing data (Appendix IV) were required to resolve the large number of different types of incompleteness or conflict. Table 43 details the frequency of incompleteness and/or conflicting information which occurred for each group and mailing. Questionnaires which were incomplete but essentially unambiguous (covered by rules 1. (a) - (e) of Appendix IV) are indicated as unambiguous in Table 43. Questionnaires with various levels of ambiguity (covered by rules 2. (ii) (a) - (v) (p) of Appendix IV) are indicated as ambiguous in Table 43.

The totals were less than they should have been for several mailing and group combinations; however, the impact of the missing data is minimal given the sample sizes involved. Questionnaires were ambiguous for different questions and at different levels of importance. Ambiguity relative to season hunted or number of days hunted was of relatively low importance and high frequency of occurrence. Ambiguity relative to kill was of relatively great importance and low frequency of occurrence (eg., 5 kills were adjusted for the second mailing of group I).

The proportion of ambiguous questionnaires was less (two-tailed test; $z = -2.68$; $n_1 = 956$, $n_2 = 266$; $P < 0.01$) for the first mailing than the second mailing of group I. This proportion was not different between mailings for group II (two-tailed test; $z = -1.13$; $n_1 = 225$, $n_2 = 53$; $P > 0.05$).

Table 43. The number of unambiguous and ambiguous questionnaires by group and mailing with frequency of occurrence of ambiguous questionnaires.

Group	Mailing	Number of questionnaires			Proportion of ambiguous questionnaires
		Ambiguous	Unambiguous	Total	
I	1	180	776	956	.188
	2	70	196	266[a]	.263
II	1	40	185	225[b]	.178
	2	13	40	53	.245
Both	Both	303	1197	1500[c]	.202

[a]Total should equal 267.
[b]Total should equal 227.
[c]Total should equal 1503.

The proportion of ambiguous questionnaires was not different between groups for either the first mailing (two-tailed test; $z = 0.36$; $n_1 = 956$, $n_2 = 225$; $P > 0.05$) or the second mailing (two-tailed test; $z = 0.27$; $n_1 = 266$, $n_2 = 53$; $P > 0.05$). When data from both groups was combined, the proportion of ambiguous questionnaires was less (two-tailed test; $z = -2.92$; $n_1 = 1181$, $n_2 = 319$; $P < 0.004$) for the first mailing (18.6%) than the second mailing (26.0%). Of all the questionnaires returned, 20.2% had some degree of ambiguity.

Tables 44 to 46 present reported information and means for the early, late, and combined seasons for the unambiguous questionnaires from the first mailing of group I. These tables can be compared directly to Tables 9 to 11 which contain data from both ambiguous and unambiguous questionnaires. One adult female and 1 immature male were reported harvested during the early season in Game Hunting Area 21 when adult males were the only legal age-sex class for that season (Table 44). Three illegal age-sex class moose were reported harvested when ambiguous data was utilized (Tables 9, 10).

Table 44. Group I - first mailing. Reported information and means for the early season (unambiguous data only).

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	2	11	0						5.50	0	
1	9	40	5		3	2			4.44	.56	8.00
2	2	9	0						4.50	0	
2A	13	58	3		3				4.46	.23	19.33
3	21	212	8		4	3	1		10.10	.38	26.50
4	14	81	3		3				5.79	.21	27.00
5	19	94	2		2				4.95	.11	47.00
6A	11	72	4		4				6.55	.36	18.00
7	32	166	8		8				5.19	.25	20.75
7A	34	214	5		5				6.29	.15	42.80
9	162	1004	35		35				6.20	.22	28.69
10	23	112	4		4				4.87	.17	28.00
11	8	37	1		1				4.63	.12	37.00
12	36	174	5		5				4.83	.14	34.80
14	39	184	2		2				4.72	.05	92.00
15	20	93	3		3				4.65	.15	31.00
15A	6	17	1		1				2.83	.17	17.00
17	29	127	7		7				4.38	.24	18.14
17A	51	242	12		12				4.75	.24	20.17
19A	18	97	4		4				5.39	.22	24.25
21	65	308	10		8	1	1		4.74	.15	30.80
21A	39	198	10		10				5.08	.26	19.80
Total	593	3548	132	0	124	6	2	0	5.98	.22	26.88

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 45. Group I - first mailing. Reported information and means for the late season (unambiguous data only).

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
1	3	8	0						2.67	0	
2	1	1	0						1.00	0	
4	2	5	0						2.50	0	
5	8	37	1		1				4.63	.12	37.00
7	8	25	1		1				3.13	.12	25.00
7A	6	21	1		1				3.50	.17	21.00
9	40	140	4		2		1	1	3.50	.10	35.00
10	4	11	3		3				2.75	.75	3.67
11	2	3	0						1.50	0	
12	23	99	4		4				4.30	.17	24.75
14	45	242	17		17				5.38	.38	14.24
15	5	14	0						2.80	0	
17	1	2	0						2.00	0	
17A	13	52	3		3				4.00	.23	17.33
21	17	67	1		1				3.94	.06	67.00
21A	17	63	2		2				3.71	.12	31.50
26	51	266	14		14				5.22	.27	19.00
Total	233	1056	51	0	49	0	1	1	4.53	.22	20.71

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

Table 46. Group I - first mailing. Reported information and means for both seasons (unambiguous data only).

Game Hunting Area	Number of hunters (total)	Number of days (total)	Number of kills						Means		
			Total	Unknown	Adult male	Adult female	Immature male[a]	Immature female[a]	Days per hunter	Kills per hunter	Days per kill
Unknown	2	11	0						5.50	0	
1	12	48	5		3	2			4.00	.42	9.60
2	3	10	0						3.33	0	
2A	13	58	3		3				4.46	.23	19.33
3	21	212	8		4	3	1		10.10	.38	26.50
4	16	86	3		3				5.38	.19	28.67
5	27	131	3		3				4.85	.11	43.67
6A	11	72	4		4				6.55	.36	18.00
7	40	191	9		9				4.78	.23	21.22
7A	40	235	6		6				5.88	.15	39.17
9	202	1144	39		37		1	1	5.66	.19	29.33
10	27	123	7		7				4.56	.26	17.57
11	10	40	1		1				4.00	.10	40.00
12	59	273	9		9				4.63	.15	30.33
14	84	426	19		19				5.07	.23	22.42
15	25	107	3		3				4.28	.12	35.67
15A	6	17	1		1				2.83	.17	17.00
17	30	129	7		7				4.30	.23	18.43
17A	64	294	15		15				4.59	.23	19.60
19A	18	97	4		4				5.39	.22	24.25
21	82	375	11		9	1	1		4.57	.13	34.09
21A	56	261	12		12				4.66	.21	21.75
26	51	266	14		14				5.22	.27	19.00
Total	690	4604	183	0	173	6	3	1	6.67	.27	25.16

[a]Immature moose refer to calves.
[b]Total hunters may be less than the sum of the column because hunters can hunt in more than one Game Hunting Area.

The Impact of Ambiguous Data on Statistics

(a) All Game Hunting Areas

When the statistic was computed from all available data, the mean number of days was greater, the mean number of days per kill was greater, and the success rate either decreased or remained stable for the early, late, and both seasons (Table 47). The proportion of licensees who hunted was 91.0% when all data was utilized and 88.9% when only unambiguous data was utilized. The kill rate decreased from 23.6% (unambiguous data) to 22.8% when all the data was utilized.

(b) Game Hunting Area 26

The mean number of days increased, the mean number of days per kill increased, and the success rate remained stable when these statistics were computed for Game Hunting Area 26 from all available data.

Table 47. Statistics computed with the use of unambiguous data and with the use of both unambiguous and ambiguous data for the first mailing of group I.

Game Hunting Area	Season	Data source	Mean days per hunter	Success rate	Mean days per kill
All	Early	UN[a]	5.98	.22	26.88
		BOTH[a]	6.27	.21	29.80
All	Late	UN	4.53	.22	20.71
		BOTH	4.63	.22	21.25
All	Both	UN	6.67	.27	25.16
		BOTH	6.82	.25	27.25
26	Late	UN	5.22	.27	19.00
		BOTH	5.38	.27	20.24

[a]UN represents the unambiguous data, BOTH represents both unambiguous and ambiguous data.

The kill rate decreased marginally from 1.8% (of all hunters killed a moose in G.H.A. 26) when unambiguous data was utilized to 1.78% when all data was utilized.

(c) Comparison of Statistics for Simulated Group to Those from First Mailing of Groups I and II

Questionnaires with ambiguous data were handled using the rules in Appendix III for the simulated group and the rules in Appendix IV for the first mailing of groups I and II. The rules detailed in Appendix IV are more comprehensive than those detailed in Appendix III. The simulated group and the combination of the first mailing of groups I and II used almost the same data base (an additional 20 questionnaires were utilized for the simulated group estimates).

The proportion of respondents who hunted was similar for the simulated group and the first mailing of groups I and II (Table 48). The success rate, kill rate, and harvest were estimated to be higher for the simulated group than the first mailing of groups I and II. The mean number of days spent hunting during the early season was higher for the first mailing of groups I and II than for the simulated group. The mean number of days spent hunting during the late season was similar between groups. The greater mean number of days spent hunting during both seasons for the first mailing of groups I and II reflected the difference for the early season.

Non-response - The Reasons

Four licensees from the sample of non-respondents returned their questionnaire after 30 April 1987 and are not included in Table 49. Of the remaining sample of non-respondents, only 27.7% were unsure if they had received a questionnaire and 26.3% indicated that they had not received a questionnaire.

The frequent reasons given for not returning a questionnaire, when at least one had been received, were that the individual didn't get around to returning it or had lost it (Table 50). Of those non-respondents who were not certain if they had received a questionnaire, more than one-half had moved or were away from their place of residence. A number of non-

Table 48. Statistics computed using the simulated group of data and the data from the first mailing of groups I and II.

Statistic	Simulated group	First mailing of groups I and II
Proportion of respondents who hunted	.914	.913
Success rate	.240	.235
Kill rate	.219	.215
Estimated harvest (5374 licenses)	1179	1154
Mean number of days spent hunting		
Early	5.88	6.23
Late	4.64	4.68
Both	6.41	6.54

Table 49. The number of non-respondents (and % of total non-respondents) who indicated that a questionnaire was received (and returned or not returned), not received, or were unsure.

Questionnaire received			Questionnaire not received	Unsure if questionnaire received
Questionnaire returned	Questionnaire not returned	Unsure		
30(14.1)	59(27.7)	9(4.2)	56(26.3)	59(27.7)

respondents indicated that they "could not recall" or "were unaware of" receiving a questionnaire and were treated as having indicated that they did not receive a questionnaire. Of those non-respondents who indicated that they did not receive a questionnaire, the majority (75%) had moved or were away from their place of residence due to employment.

One reason for non-response is that a questionnaire may not get to

the individual who purchased the license. This may result from incomplete or undecipherable addresses on the license stubs which are received from vendors (eg., Fig. 1).

Table 50. The frequency of reasons cited by non-respondents for not returning a questionnaire. Comments by non-respondents who indicated that they did not receive a questionnaire or were unsure if they had received a questionnaire are included.

Reason	Number of non-respondents		
	Questionnaire received and not sent	Unsure if questionnaire received	Questionnaire not received
Didn't get around to completing questionnaire or sending it	29		
Lost questionnaire or filled it out and then lost it	10		
Too busy	4	1	
Moved away from place of residence due to job	3	5	9
Didn't think questionnaire was important	2	1	
Unsuccessful and thought information unimportant as a result	5		
Treated as junk mail, seldom examines mail		3	
Fed up with management of moose, rules, number of moose, lack of success, Treaty rights, harassment by N.R.O. staff (i.e., didn't want to cooperate)	4		3
Illiterate in English	1		

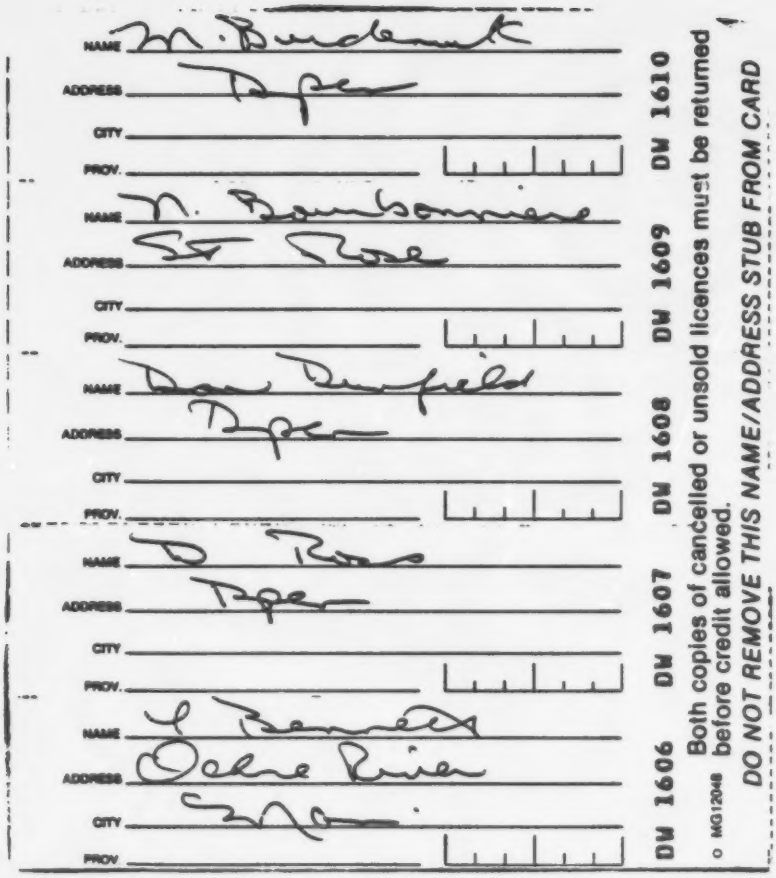
NAME
ADDRESS
CITY
PROV.
DW 1606 DW 1607 DW 1608 DW 1609 DW 1610
Both copies of cancelled or unsold licences must be returned before credit allowed.
MG12048
DO NOT REMOVE THIS NAME/ADDRESS STUB FROM CARD

Fig. 1. An example of incomplete and illegible names and addresses on license stubs submitted by vendor.

Representativeness of the Sample of Non-respondents

A total of 217 from the sample of 250 non-respondents were contacted (86.8% of the sample). The previous data relative to the impact of non-response bias on harvest estimation are based on the assumption that the sample of non-respondents is representative of all the non-respondents. A substantial effort was made to contact the complete sample of non-respondents; however, a number of individuals were not contacted. If the characteristics of the non-respondents who were not contacted differ substantially from those who were contacted, the inferences made on the basis of the above assumption will be somewhat in error.

Table 51. Number of non-respondents contacted, total non-respondents, and proportion of non-respondents contacted by region for a sample of 250 non-respondents.

Region	Number of non-respondents contacted	Total number of non-respondents	Proportion of non-respondents contacted
Eastern	7	11	63.6
Interlake	26	28	92.9
Northeastern	47	60	78.3
Northwestern	34	41	82.9
Southeastern	57	59	96.6
Southwestern	14	16	87.5
Western	32	35	91.4
Total	217	250	86.8

The proportion of non-respondents who were contacted varied between regions (Table 51). These regions are those used by the Wildlife Branch as administrative units prior to the division of Southwestern Region into 2 units. The high proportion of non-respondents contacted in the Southeastern Region results primarily from the 95.2% (40/42) of non-respondents from Winnipeg who were contacted by the author. A higher

proportion of Winnipeg resident non-respondents were contacted (95.2%) than non-respondents who resided outside of Winnipeg (85.1%).

A significant proportion (one-third) of the non-respondents who were not contacted had moved (Table 52), some out of the province (eg., 2 individuals from Leaf Rapids had moved to Hemlo, Ontario). Another one-third of non-respondents were virtually impossible to contact at their listed place of residence which suggests that they may have been working away from their residence or have moved.

Geographic Distribution

Appendix V details the geographic distribution (place of residence) of 94.3% of the hunters who purchased a license for the 1986 general moose season. Geographic distribution is detailed separately according to date by which stubs had been received (20 January 1987 for group I and 15 February 1987 for group II). Hunters whose place of residence was Winnipeg purchased 831 of these 5065 general moose licenses (16.4%). Substantial numbers of licenses were purchased by hunters from Thompson (492), The Pas (325), Flin Flon (197), Leaf Rapids (151), Lynn Lake (137), Snow Lake (122), and Cranberry Portage (105).

Table 53 summarizes the data from Appendix V into geographic distribution by Game Hunting Area. The determination of Game Hunting Area for each location was made utilizing Game Hunting Area boundaries for 1986. In those cases where geographic locations fell on the boundary between 2 Game Hunting Areas, the number of hunters was divided equally between the 2 Game Hunting Areas. If the number of hunters was an odd number, the additional hunter was randomly assigned to one of the Game Hunting Areas. Appendix VI details the allocation of hunters between Game Hunting Areas for those geographic locations situated on a boundary.

The greatest proportion of the general moose hunters resided within Game Hunting Area 9. Winnipeg residents (Game Hunting Area 38) comprised a similar proportion of the hunters who purchased a general moose license. The proportion of hunters who resided within Game Hunting Area 6A was represented by hunters whose place of residence (mailing address) was The Pas.

Table 52. Information relative to some of the non-respondents who were not contacted.

Comment	Number of non-respondents						
	Interlake Region	Northeastern Region	Northwestern Region	Southeastern Region	Southwestern Region	Western Region	Total
Moved	1	4	3				8
Appears to have moved					1		1
Phone disconnected	1					1	2
Away from residence due to job		1	1				2
Individuals resident at address on license stub did not know non-respondent		1		1			2
Could not contact non-respondent despite several attempts at place of residence or through mailing address		5	2	1			8
General delivery listed as mailing address			1				1

Table 53. Geographic distribution by Game Hunting Area of hunters who purchased a license for the 1986 general moose season.

Game Hunting Area	Number of hunters	Proportion of total hunters
1	2	.04
2	63	1.24
2A	7	.14
3	56	1.11
4	252	4.98
6A	325	6.42
7	117	2.31
7A	123	2.43
9	930	18.36
10	67	1.32
12	29	.57
13	33	.65
13A	75	1.48
14	131	2.59
15A	6	.12
16	20	.39
17	22	.43
17A	3	.06
18A	46	.91
19	70	1.38
19A	160	3.16
19B	17	.34
20	11	.22
21	29	.57
21A	42	.83
22	48	.95
23	11	.22
23A	36	.71
24	47	.93
25	209	4.13
25A	94	1.86
25B	321	6.34
26	55	1.09
27	23	.45
28	75	1.48
30	80	1.58
31	62	1.22
31A	11	.22
32	5	.10
33	71	1.40
34	107	2.11
34A	101	1.99
34B	44	.87
35	7	.14
35A	164	3.24
36	25	.49
38	831	16.41
Wasagaming	1	.02
Richmond, B.C.	1	.02

Response Rate by Geographic Location

Appendix VII details the number of hunters responding to the first or second mailing of the questionnaire and the number of non-respondents for a sample of 1986 general moose hunters. The data contained within Appendix VII is subject to a small error because the number of hunters total 2546 when it should total 2551. The response rate (56.5%) is lower than the response rate for the estimate of non-response bias (58.9%). This difference results principally from additional questionnaires being returned between compilation of the data in Appendix VII (6-15 April) and sampling of the non-respondents (30 April). Subsequently, the response rates for some of the geographic locations in Appendix VII are somewhat lower than what they would have been when the random sample of non-respondents was conducted.

It is apparent from Appendix VII that response rate is quite variable between locations. The response rate was relatively low for hunters from Camperville (15.8%), Barrows (20.0%), Cormorant (26.9%), Bissett (27.3%), Moose Lake (27.3%), Duck Bay (27.8%), and Mafeking (34.6%). The response rates of hunters from Teulon (80.0%), Shilo (75.0%), Portage la Prairie (72.7%), Gimli (68.0%), Bowsman (66.7%), and Beausejour (65.4%) were considerably higher than the average response rate. The response rate of hunters from Winnipeg (64.4%) was greater (two-tailed test; $z = 3.50$; $n_1 = 402$, $n_2 = 2144$; $P < 0.005$) than that of rural residents (55.0%).

DISCUSSION

Response Rate

The response rate to 2 mailings was similar for groups I, II, and III despite different periods between mailings for groups I and II as compared to group III. This suggests that response rate is influenced marginally, at best, by the period of time between mailings when periods of 30 days and approximately 2 months are compared. The response rates to the first mailing for groups I and II were similar to those recorded in recent years when only 1 mailing was conducted (see Table 54). Response to the first mailing was likely facilitated somewhat by the presence of a second mailing; however, some respondents to the second mailing would have

responded in the absence of a second mailing. The group of respondents to the first mailing is therefore not exactly representative of the group which would have resulted if only 1 mailing was conducted. Although these rates represent response to the first mailing, the similarity to past rates (1 mailing only) suggests that estimates generated from this data should realistically approximate estimates which would have resulted if only 1 mailing had been conducted (i.e., the standard method).

It is impossible to determine the exact benefit of the second mailing; however, it is believed that increases in response rate of 13.0% (group I) and 10.9% (group II) constitute reasonable estimates. For the second mailing of group I, 58%, 81%, and 90% of the total returns were received by 2, 3, and 4 weeks respectively after mailing. These figures were slightly lower for the first mailing of group I which reflects the longer period of time between the mailing date and 30 April 1987. The rates at which responses were received are results specific to this study in that each mailing would have influenced return of the other mailing (eg., the return of questionnaires from the first mailing was likely enhanced by the timing of mailing the second questionnaire).

Illegible Questionnaire Numbers

The inability to identify respondents likely resulted in some of these respondents being included in the group of non-respondents. The maximum number of respondents which could have been included with the non-respondents is 28; however, the number would likely have been less because some of these licensees may have responded to the other mailing. These potential respondents represent only 2.7% of the sample of non-respondents and should have had little influence on estimates generated for the response and non-response groups.

Response Bias

Response bias may occur when the information provided by respondents contains answers which are wrong. A bias will result if the incorrect answers are not random (i.e., do not cancel one another). Response bias may result from systematic errors (eg., a hunter who hunts in an open G.H.A. may indicate hunting in an adjacent G.H.A. which is closed -

this type of error could result in bias) or may result from intentional wrong answers by the respondent. MacDonald and Dillman (1968) indicated that respondents to a deer harvest questionnaire reported killing a greater proportion of adult males than actually occurred. This type of bias has been called "brag" bias, the belief being that some hunters do not want to report killing a fawn. Some of this bias may have resulted from an inability of some hunters to correctly identify the age of their deer, a mechanical error (checking the wrong box), or the questionnaire having been answered by the wrong individual (10.7% of the hunters who had killed an adult male reported killing a different age/sex class in MacDonald and Dillman's (1968) study). Two Manitobans who have tagged 1 moose between them will sometimes both indicate having tagged a moose when responding to a questionnaire (D. W. Soprovich, Manitoba Wildlife Branch, unpubl. data). This type of response bias would lead to inflated estimates of harvest.

The rules detailed in Appendices III and IV represent attempts to utilize all available data while standardizing any response bias which could result. Response bias might be controlled by not utilizing ambiguous data; however, such a procedure could result in another bias. For example, if one was interested in kill rates and only data ambiguous relative to kill rate was deleted (and data with other ambiguities retained), an underestimation of kill rate would likely result (some of the ambiguous questionnaires would likely represent successful hunters). A decision would have to be made relative to the level of ambiguity at which data was acceptable. The rejection of all data which were ambiguous (at any level) could result in another bias. Questionnaires which are ambiguous may relate to the literacy, in English, of the individual completing the questionnaire. A bias would result if kill rate (or any other statistic) were related in an associative sense (not functionally) to literacy in English. The approach taken during this study was that each return contained some valuable information. This information was then utilized in accordance with the rules developed to handle ambiguous data. Some response bias is inevitable; however, utilization of the rules should standardize the bias.

The rules detailed in Appendix III were used to handle ambiguous data for the simulated group. The reported information for this group of data included Game Hunting Areas which were not legally open to general

moose licensees (G.H.A.'s with no moose season, G.H.A.'s open to general moose hunters during the early or late season only) and the reported harvest of an age/sex class which was illegal. The illegal Game Hunting Areas likely resulted principally from the small scale of the map included with the questionnaire and the unfamiliarity of some hunters with the location of their hunt (e.g., some hunters would have gone along with a friend without being aware of exactly where they were hunting). The report of illegal kill could reflect an error on the part of the hunter in identifying the age and/or sex of the tagged moose, an error in reporting the Game Hunting Area where the moose was killed (some G.H.A.'s had seasons for a moose of any age/sex, other G.H.A.'s did not), or an actual illegal kill (unknown to the hunter?). A report of an illegal kill could also result from response by an individual other than that to whom the questionnaire was addressed. Wright (1978 in Filion 1980) estimated that 7% of the respondents to a waterfowl harvest questionnaire were not the individuals sampled. The illegal kill reported for the simulated group was an adult female in Game Hunting Area 21 from the early season. A draw season was held in the adjacent Game Hunting Area 21A during the late season with a legal bag of any moose. It is possible that the individual reporting the illegal kill was one of the successful licensees for the above season who erroneously indicated the season and Game Hunting Area of kill.

The rules detailed in Appendix IV were used to handle ambiguous data for groups other than the simulated group. These rules are considerably more comprehensive than those used for the simulated group. The 2 sets of rules were similar in application to allow comparison between the simulated group and other groups.

Unlike the reported information for the simulated group, the reported information for groups I, II, and III does not contain data from Game Hunting Areas which did not have an open season. The rules utilized for the simulated group do not discuss the handling of reported kills which were not legal. The approach used for groups I, II, and III was to utilize the age/sex as reported (rather than adjusting the age/sex) with assessment of the accuracy being left to the discretion of the individual utilizing the data. This approach resulted in a number of the kills being illegal as reported. As previously discussed, these reported illegal kills may result

from an error made by the respondent or may represent actual illegal kills. The 2 reported illegal kills from Game Hunting Area 21 may result from the questionnaires having been answered by someone other than the individual to whom the questionnaire had been addressed (someone who had a license for the draw season in Game Hunting Area 21A). An adult female was reported killed in Game Hunting Area 9 during the early season (group I, second mailing). It is possible that this kill occurred during the late season and was erroneously reported as having occurred during the early season.

Despite the fact that data used for the simulated group was almost identical to that for the first mailing of groups I and II, the reported kill of illegal age/sex classes and the reported Game Hunting Areas which were not open differed between the data sets. These discrepancies are evidence of how the same set of data (essentially) may be summarized to yield different results despite similar rules for the treatment of ambiguous information (i.e., the handling of response bias). A consistently applied methodology for handling response bias (ambiguous information) is implicated as important to the comparability of information.

The 2 sets of data (simulated group and combination of groups I and II - first mailing) with their respective rules for handling ambiguous data differed relative to several statistics. The proportion of licensees who hunted was slightly higher, the success rate greater, and the kill rate greater for the simulated group. The harvest was estimated at 1179 moose for the simulated group and 1154 moose for the first mailing of groups I and II. The mean number of days spent hunting was greater for the first mailing of groups I and II during the early season and similar for both data sets during the late season.

The proportion of licensees hunting, success rate, kill rate, and harvest did not differ considerably. This result was expected because it was necessary to model the rules of Appendix IV after those of Appendix III to allow comparability. The differences between sets of data relate to the additional 20 records included in the simulated group and/or the application of two slightly different (relative to comprehensiveness in particular) sets of rules by 2 different individuals. The kill rate would have had to have been 50% for the additional 20 records for this difference in kill rate and harvest estimate to be attributable solely to the additional records. Given

the above event being highly unlikely and the previously discussed differences between data sets (relative to reported age/sex classes which were illegal and Game Hunting Areas which were not open), it is likely that the differences relative to kill rate relate to a large extent from the application of the 2 sets of rules by 2 different individuals. These differences in statistics are important because:

(a) they indicate that methodology will influence the absolute value of these statistics (i.e., the statistics can be influenced by the application of different rules by different individuals to (essentially) the same set of data) and

(b) the estimate generated by 2 independently working individuals (with similar rules) are similar enough that this source of error should not critically influence the ability to compare estimates on an annual basis. The 2 estimates should have been closer if only 1 set of rules had been strictly adhered to (e.g., those of Appendix IV).

The difference in harvest estimate between sets of data does indicate that it is important to maintain a standard methodology in the handling of ambiguous data. A standard methodology will minimize the impact of individual variability in the utilization of such data.

There were various types of ambiguity (relative to kill, number of days hunted, etc.) with differing levels of importance and frequency of occurrence. A considerable proportion (20.2%) of the responses from groups I and II contained some level of ambiguity. The proportion of ambiguous responses generally increased from the first to the second mailing. The ability to recall may relate to time elapsed since occurrence of the event and motivation or interest in the event (Filion 1980). The time between response and the hunting event would have been greater for respondents to the second mailing. It is also likely that respondents to the second mailing were less interested in hunting moose and less motivated to respond (as a result) than respondents to the first mailing (for example, proportionately more respondents to the first mailing for group I hunted during both seasons). These 2 reasons may be responsible for the generally greater proportion of ambiguous responses among questionnaires returned from the second mailing.

The addition of data containing ambiguities (and the application of the rules in Appendix IV) resulted in an increase in the mean number of days spent hunting, an increase in the mean number of days per kill, and a decrease (or no change) in success rate as compared to the group of data containing no ambiguities for the first mailing of group I. The proportion of licensees who hunted increased while the kill rate decreased from 23.6% to 22.8% when ambiguous data was used. It would appear that the individuals who supplied ambiguous data hunted more frequently (proportion of licensees hunting) and perhaps more days (this may be a real difference but may be a function of recall bias) while being less successful. The difference between unambiguous and ambiguous data may be a real difference or may simply be a function of the inability of the rules (Appendix IV) to accurately handle ambiguous data. Filion (1980) discusses several methods of dealing with recall bias but suggests that any method should be used with caution.

Bias Due to Incomplete Sampling

The license stubs included in group I represent stubs which were remitted by vendors earlier than those included in group II. Stubs from 5.1% of the licenses purchased were either lost or received too late (groups III, IV, V) to be included in the normal procedure for harvest estimation (i.e., received too late to be included in estimates for 30 April).

Similar response rates allow fair comparison of groups I to III. Hunters from group I hunted less frequently during the late season, more frequently during both seasons, and harvested proportionately less moose from the winter season than those from group II. The spatial distribution of hunters during the late season differed as did the mean number of days hunted (although this statistic was not subjected to statistical test and recall bias could influence such a statistic differentially when comparing groups I and II). The success rate (24.4% versus 18.1%) and the kill rate (21.8% versus 15.7%) were substantially greater for group I. The proportion of licensees who hunted was the only statistic examined which did not differ between groups I and II (at $P \leq 0.05$).

Respondents from group III harvested a greater proportion of their moose during the late season, hunted more frequently in Game Hunting Area 26

during the late season, hunted an average of fewer days during the early season, more days during the late season and fewer days during both seasons, and were less successful than respondents from groups I and II. These results are consistent with what is expected on the basis of the differences between groups I and II (i.e., the expected trends appear to exist). The proportion of hunters who hunted during the late season, the proportion hunting during both seasons, and the kill rate were intermediate between groups I and II (although relatively close to group II). The expected trends are not supported for these statistics (although they were considerably different and in the expected direction from group I); however, it is important to recognize that the sample size for group III was small (55). The proportion of licensees who hunted was higher for group III than for the other 2 groups (this statistic was the only one not significantly different at $P \leq 0.05$ for groups I and II). Kill rate was the only statistic tested statistically between groups and did not differ significantly for group III as compared to groups I and II. The other statistics were not tested between groups due to the small sample size.

The evidence relative to differences between groups supports the contention that license stubs remitted early are also those which are purchased early (in general). A much greater proportion of the license stubs remitted for group II consisted of groups of 1, 2, 3, and 4 stubs as compared to those remitted for group I (primarily complete groups of 5 stubs). This evidence also suggests that the license stubs remitted early are those which are purchased early. Hunters who purchase their license relatively early would be expected to hunt more frequently during the early season (less so during the late season) and to hunt more frequently during both seasons. It would also be expected that hunters who purchase their licenses relatively early would be more successful. These hunters would have the opportunity to hunt moose for a greater period of time and may generally represent hunters who are most interested in hunting moose (and purchase their licenses early). Hunters who are most prone to respond are generally most interested in their avocation and most successful (Filion 1980).

The above results clearly indicate that the hunters whose license stubs are returned early by vendors are not representative of hunters in

general. If only the stubs from group I had been sampled (i.e., the stubs received earliest), harvest and kill rate would have been overestimated and a greater proportion of the harvest would have been estimated to have occurred during the early season. The distribution of hunters (and likely harvest) would be significantly biased for some Game Hunting Areas (e.g., G.H.A. 26). It is important to recognize that incomplete sampling will result in biased estimators for almost all of the statistics examined (the proportion of licensees hunting was the only statistic examined which was not different between groups). The extent of the bias will likely be variable as a function of the degree of completeness/incompleteness of the sampling.

Non-response Bias

Harvest and other estimates generated from questionnaire data during recent years (the 80's) in Manitoba have been made with the assumption that respondents to questionnaires are representative of non-respondents. With respect to harvest, the assumption has been that the kill rate of non-respondents is the same as respondents to the questionnaire. The assumption that respondents are representative of non-respondents is usually a poor assumption for self-reporting methods of estimation like questionnaires (Filion 1980). The individuals who respond most quickly are generally those most interested in the subject in question and will usually differ from those who do not respond. As one probes further into the continuum of response (i.e., the enhancement of response through additional mailings), one effectively probes further into a continuum of interest in the subject at hand (in general). The net effect of non-response, given differences between respondents and non-respondents, is that estimates are biased in a consistent and predictable direction. In the case of harvest estimates of big game, a number of studies have shown that estimates are biased upwards (i.e., overestimate the true harvest) as a result of non-response bias (Bossenmaier and MacPherson 1964; MacDonald and Dillman 1968; McPhillips et al. 1985; Grauvogal 1987).

Respondents to the second mailing differed from respondents to the first mailing relative to several of the statistics examined. The proportion of licensees who hunted and the proportion of hunters who hunted

during both seasons was substantially less for respondents to the second mailing. Some of these respondents to the second mailing may not have responded to the first mailing because they felt that the Wildlife Branch would not be interested in their response <u>because</u> they did not hunt (and did not kill, etc.). These differences are evidence in support of the hypothesis that later, less motivated respondents are less interested in hunting moose. At the same time, the mean number of days spent hunting during both seasons was almost identical for respondents to either mailing. The comparison of mean number of days spent hunting may be weak because recall bias may have influenced this statistic differentially between mailings. The questionnaires from respondents to the second mailing contained a greater proportion of ambiguous data which may have influenced these estimates differentially. The mean number of days spent hunting would also have been influenced slightly by the success rate of respondents to the first mailing being higher than that of respondents to the second mailing. In general, however, the data relative to the mean number of days spent hunting does not provide support for the hypothesis that later, less motivated respondents are less interested in hunting moose (at least, for those respondents who actually <u>hunt</u>).

The success rate and the kill rate were greater for respondents to the first mailing, as hypothesized, but these hypotheses were not supported statistically (at $P \leq 0.05$). The difference in kill rates resulted in a low P value for a test of the hypothesis that kill rate for respondents to the first mailing was greater. It is likely that the lack of statistical significance reflects the relatively small difference between rates in concert with the size of the sample rather than lack of a real difference.

Non-respondents differed considerably from respondents (to 2 mailings) with respect to a number of characteristics. A greater proportion of hunters from the non-respondent group hunted during the late season. This was a function, in part, of the relatively high proportion of hunters (<u>total</u> hunts) who hunted in Game Hunting Area 26 among non-respondents (13.5%) as compared to respondents (7.5%), a difference apparent for <u>late</u> season hunters also. The proportion of harvest from the late season was less for non-respondents; however, this difference was not statistically significant ($P < 0.14$). The smaller proportion of harvest from the late

season, despite a greater proportion of hunters, resulted from the substantial disparity in success rate between early season hunters (17.3%) and late season hunters (6.1%) for non-respondents. The non-respondents averaged fewer days hunting moose than respondents. This difference may or may not be real as it could be influenced by differential recall bias. The fact that data from respondents was collected by 1 method (questionnaire with its accompanying rules for handling ambiguous data) and data for non-respondents collected by another method (personal contact) would very likely have influenced estimates differentially to an unknown degree. Personal contact allows the flexibility to ask further questions if answers are not clear (eg., if an individual answers "September" to the question regarding the number of days hunted, the interviewer can ask further questions to ascertain the number of days hunted). The proportion of hunters who hunted during both seasons, although not statistically different between groups, was surprisingly higher for non-respondents.

The proportion of licensees who hunted was not greater for respondents than non-respondents as had been expected. This proportion was actually higher for the non-respondents as a result of the low proportion among respondents to the second mailing. It may be that respondents to the second mailing responded for somewhat different reasons (including having not responded to the first mailing because they had not hunted and did not think their information important) than those individuals who did not respond to either mailing. The success and kill rates were considerably lower for non-respondents, as expected given the findings of previously cited studies.

The result that non-respondents spent an average of fewer days hunting moose than respondents (despite the difficulties in making this comparison) tends to support the hypothesis that non-respondents are less interested in hunting moose. The comparison of non-respondents and respondents relative to other characteristics suggests that the hypothesis is incorrect. The proportion of hunters who hunted during both seasons, although not statistically different between groups, was actually higher for non-respondents contrary to expectations. The proportion of licensees who hunted was also higher for non-respondents and contrary to expectations (and not statistically different). As expected, the success rate and the

kill rate were considerably higher for respondents than non-respondents. The characteristics examined for both respondents and non-respondents do not support the hypothesis that individuals who respond are more interested in hunting moose and therefore respond (note that this discussion pertains to 2 mailings with an approximately 60% return rate). The evidence supports the hypothesis that response is motivated by success (or inhibited by a lack thereof) which leads to the biased estimates which result when non-response occurs.

Of the licensees who indicated having received a questionnaire, a large proportion indicated that they did not return the questionnaire for reasons related to a relative lack of interest (eg., "Didn't get around to it", "Too busy", "Lost the questionnaire"). At the same time, a number of licensees indicated not having returned questionnaires because they didn't think the questionnaire was important or don't examine their mail closely. A number of non-respondents had moved, worked at a location distant from their mailing address, or were illiterate in English. Some individuals indicated that their recent moose hunting experience had been unsatisfactory, they were upset with present moose management, and chose not to cooperate. It is apparent that non-response results for a number of reasons additional to interest in hunting moose. The influence of these other factors may be part of the reason that respondents and non-respondents did not differ relative to the proportion of licensees who hunted and the proportion of hunters who hunted during both seasons. Several of the non-respondents who were upset with present moose management also indicated having been unsuccessful. Additional non-respondents indicated that they did not respond because they had not been successful and thought that the Wildlife Branch wouldn't be interested in their response. These reasons for not responding lead to the biased harvest estimates which result from non-response.

A significant proportion of the non-respondents indicated that they had returned a questionnaire. Some of these individuals may have supplied an incorrect answer as a function of their ability to recall (a substantial time interval had elapsed between when the questionnaires were mailed and June and July when the majority of the non-respondents were contacted). An incorrect answer may have been supplied by some non-

respondents due to the nature of the question and the direct personal method of contact (i.e., they may not have wanted to indicate that they had been irresponsible in not responding). These reasons may have contributed to the high proportion of non-respondents who indicated returning a questionnaire; however, the proportion is great enough that some of these individuals must have returned questionnaires. It would appear that questionnaires are being lost between being received by Canada Post and being received by the Wildlife Branch.

Of the non-respondents contacted, the majority indicated that they had received a questionnaire or were unsure if they had received a questionnaire. Only 26.3% indicated that they had not received a questionnaire. These figures may be somewhat inaccurate given the period of time between the event and when the individuals were asked to recall the event. As such, the figures should be treated as approximations of what did occur. It appears that a substantial proportion of non-respondents received the questionnaire (a large proportion of individuals who were unsure may have received their questionnaire) and did not respond for the variety of reasons already discussed. Questionnaires may not have been received by some individuals because they had moved, they worked away from their mailing address, or their address was not legible or accurate on their license stub. Some of these reasons are beyond control of the resource manager (eg., individuals who move or give false addresses); however, a number of these reasons for non-response can and should be addressed to enhance response.

It is important to recognize that the comparison of respondents and non-respondents with respect to <u>all</u> the characteristics examined is made for statistics collected with different methodologies. Both of these methodologies are subject to response bias to an unknown degree. The treatment of ambiguous data may have been such that a statistic like kill rate may have been overestimated for the respondents. Additionally, some respondents may have indicated tagging a moose that was actually tagged by a member of their party or some respondents may have indicated tagging a moose when they did not kill one ("brag" bias). Some individuals contacted personally during the collection of data from non-respondents may have provided inaccurate information because they felt that their privacy was being invaded. The comparison of statistics for the 2 groups will likely

have been influenced somewhat for the above reasons.

Not all of the non-respondents in the sample were contacted. If the individuals who were not contacted differed from those who were contacted, the estimates derived for the non-respondent group would be biased and comparison to the respondent group subject to error. The proportion of Winnipeg resident non-respondents contacted was higher than the proportion of rural resident non-respondents. Bossenmaier and MacPherson (1964) estimated that the success rate of Winnipeg resident hunters was 20.7% and that of rural resident hunters 36.9% for the 1963 moose season. If Winnipeg resident hunters were less successful (and kill rate lower) than rural resident hunters for the 1986 general moose season, a bias towards underestimation for non-respondents could have resulted because proportionately more Winnipeg residents were contacted. The proportion of non-respondents contacted varied from region to region which could have introduced a bias into estimates for non-respondents (particularly by geographic area). Of the non-respondents who were not contacted, a number had moved (likely the reason for some of them not responding) while others were often away from their mailing address and difficult to contact (eg., working in "the bush" or at Limestone). It is likely that the characteristics (relative to success rate, kill rate) for these non-respondents would not differ that greatly from the non-respondents who were contacted. Given the large proportion of the non-respondent sample which was contacted and the likelihood that the non-respondents contacted do not differ radically from those not contacted, the estimates derived for the non-respondent group should be quite accurate.

Harvest Estimation

Estimates of harvest for the simulated group are believed to be representative of estimates which would have resulted if the standard methodology had been used (i.e., 1 questionnaire) to estimate harvest for the general moose season. The response rate for the simulated group is similar to response rates achieved between 1981 and 1985 (Table 54). Some of the rates in Table 54 relate to satisfactory returns only; however, it appears that relatively few returns were deemed unsatisfactory for the years 1980 to 1985 (see data for 1980 and 1981). The response rate for 1980

Table 54. Statistics important to the estimation of harvest for the general moose season for the years 1974 and 1980 to 1986.

Year	Number of licenses purchased	Sampling intensity (%)	Sample size	Proportion of license purchasers sampled[a]	Number of mailings	Number of questionnaires returned	Response rate (%)	Number of satisfactory returns[b]	Proportion of sample upon which estimate was based (%)
1974[b]	9296	22.8[c]	2124	100.0(?)	3[d]	1853	87.2	1702	80.1
1980	7768	22	1575	92.2	1?	900	57.1	885	56.2
1981	7429	40	2651	89.2	1	1164	43.9	1155	43.6
1982	7451	?	2521		1?			1092	43.3
1983	6692	?	3945		1?			1771	44.9
1984	6216	25	1334	85.8	1			652	48.9
1985	5240	50	2426	92.6	1			1159	47.8
1986[e]	5374	50	2551	94.9	1	1203	47.2	1203	47.2

[a]Estimated by multiplying sample size by (100 divided by sampling intensity) to give population (of licensees) from which sample was made and then dividing this figure into number of licenses purchased; the complete population of licenses (9296) was sampled at the 22.8% rate during 1974.
[b]All moose licenses in Manitoba were available by draw only for specific management units.
[c]Sampling intensity was 22.8% overall but varied by management unit.
[d]Peggy Westhorpe, Manitoba Wildlife Branch, pers. commun.
[e]Estimation via standard method.

was considerably higher than that for the simulated group but it is unclear if only 1 mailing was conducted for 1980. The response rate achieved from the first mailing for group I before any returns from the second mailing were received was almost as great as those likely achieved for the years 1981, 1982, and 1983. This information supports the use of the simulated group as a reasonable estimator of what harvest would have been under conditions of standard methodology.

As expected based upon previous studies which examined the influence of non-response bias on harvest estimates (Bossenmaier and MacPherson 1964; MacDonald and Dillman 1968; McPhillips et al. 1985; Grauvogal 1987), the standard methodology (simulated group) overestimated harvest significantly. As harvest estimates for the simulated group were based upon 5354 total licenses (compared to 5374 licenses for the non-response bias adjusted estimates), the standard methodology would have overestimated harvest by a slightly greater amount if the final figures for total licenses purchased had been used. The relatively great overestimation of harvest for the late season results not only from the general impact of non-response but from the very poor success of non-respondents who hunted during the late season (despite a relatively high proportion of non-respondents hunting during the late season). Inclusion of data from non-respondents not only resulted in more realistic estimates but also resulted in tighter 95% confidence limits (and realistic confidence limits).

Harvest for Game Hunting Area 26 was believed to have been overestimated by 64.4% by the standard method. The kill rate (number of moose killed in G.H.A. 26 divided by total licensees) was lower for non-respondents than respondents to the first mailing (essentially equivalent to the simulated group) despite a greater proportion of hunters hunting in Game Hunting Area 26 among the non-respondents (13.5% of total hunts for non-respondents and only 8.2% for respondents to the first mailing). The difference in kill rate results from the substantial difference in success rate between respondents to the first mailing and non-respondents.

The comparison of estimates from the simulated group and the non-response bias adjusted group is subject to the effect of response bias (errors occurring for both unambiguous data and the handling of ambiguous data). The sample size for kill from the non-respondent group is also

relatively small and estimates would be sensitive to additional kills if they were reported from Game Hunting Area 26. Despite these cautions relative to the results, the results are in agreement with expectations based on past studies and are in agreement and lend support to Crichton (Manitoba Wildlife Branch, pers. commun.) who indicated that the questionnaire method has substantially overestimated harvest from Game Hunting Area 26 in the past (on the basis of results from check stations).

The harvest estimate for the standard methodology was particularly bad for Game Hunting Area 26. It appears that hunters from Game Hunting Area 26 generally respond if they kill a moose (success rate of 23.1% among respondents) but rarely have killed a moose if they do not respond (2.9% success rate among non-respondents). This is an interesting finding in that it may result from the significant management effort (i.e., check stations) which occurred from prior to 1972 to 1982 for Game Hunting Area 26. It would appear that hunters from this Game Hunting Area cooperate by submitting their questionnaires if they have killed a moose (in most cases). This cooperation may result from the years of close contact between hunters from this Game Hunting Area and personnel from the Wildlife Branch. The severe non-response bias appears to result because hunters from Game Hunting Area 26 who do not kill a moose are unlikely to respond. It is ironic that this apparent form of cooperation seems to have led to extremely biased harvest estimates when the standard questionnaire methodology is used.

Accuracy of the Modified Wave Method

(a) Non-response Bias

The development of a linear relationship between kill rate and response rate with the use of successive waves of response has been proposed as 1 method for the control of non-response bias (Filion 1980). The standard method has been to separate waves on the basis of time (F. Filion, Environment Canada, pers. commun.), i.e., questionnaires which arrive within any given block of time become the wave for that block of time (waves I, II, III, etc. for successive blocks). It should be noted that multiple mailings on a regular basis are a component of the methodology for

this system. The waves could be formed on the basis of the initiation of return of questionnaires from the second, third, etc., mailings.

Filion (1980) indicated that the estimates would be most valid when based on data from at least 3 mailing waves and a total response rate in excess of 60%. The estimates of harvest for this study are based upon 2 mailings only and response rates of 46.4% for the first wave and 58.9% for the second wave. In addition, the first wave consisted of responses to the first mailing (regardless of when they were received) and the second wave consisted of responses to the second mailing. This methodology is therefore modified from that indicated by Filion (Environment Canada, pers. commun.). Successive waves (when waves are related directly to time) are assumed to probe deeper into the core of non-respondents (from the continuum of highly motivated to unmotivated individuals) with kill rate decreasing from wave to wave (Filion 1980). In this study, the large majority of responses to the first mailing were received prior to responses to the second mailing therefore waves (on the basis of mailing) are indirectly related to time. The waves from this study, although constructed in a slightly different fashion from the standard method, would still be expected to represent groups of individuals with differing levels of motivation (and kill rate). The 2 different methods used to construct waves would likely lead to similar results because of this common basis.

The modified wave method resulted in harvest estimates which were quite accurate. This method overestimated harvest by only 2.1% for the early season, 3.5% for the late season, and 2.6% for both seasons combined (when compared to the non-response bias adjusted estimates). These errors are relatively small and considerably less than the errors resulting from the standard method (simulated group). The wave method produced a total harvest estimate which was much more accurate than use of the kill rate from either both mailings combined or the second mailing for non-respondents.

Filion (1980) indicated that the wave method (the extrapolation) could result in error if the "hard core" non-respondents differed from late respondents and upset observed trends. This is equivalent to the concern that the slope developed from the data (and the line-of-best-fit over the range of response rates for which data exists) is actually less (more negative) beyond the last data point (when extrapolation begins) leading to

an overestimate of the true harvest. The best estimate of harvest (non-response bias adjusted) was overestimated by the wave method for the early, late, and both seasons combined thereby providing evidence for the legitimacy of this concern. It should be noted; however, that the method for constructing waves in this study would very likely have resulted in slightly lower kill rates for the first wave than would have resulted with the standard method (as later, likely less successful questionnaires from the first mailing were included in the first wave). This methodology difference could have been responsible for the overestimate.

(b) Incomplete Sampling Bias

As the sampling frame was not complete, the wave method was applied to several statistics to provide estimates for these statistics at complete sampling. The critical assumption in this application, as in the use of the wave method to control non-response bias, is that the statistic in question is related to the proportion of stubs sampled (response rate in the non-response bias application) in a linear fashion. An additional assumption is made that the slope of the computed line-of-best-fit does not change beyond the last data point (extrapolation to 100% sampling).

The wave method was applied to sample points ("waves") which represented 76.8% and 94.9% of the total licenses. The response rates for both groups were similar and it was assumed that non-response bias would be similar for each group. The use of groups with widely different response rates would seriously impact this method. It is critical to recognize that the estimate for kill rate is an index because it was not corrected for non-response bias. The estimate for the proportion of the total harvest from the late season is likely an index - this proportion was not statistically different ($P < 0.07$) between respondents and non-respondents but it is likely that this results from a small sample size.

The data from group III supported the use of this technique to provide more accurate index estimates. The response rate for group III was comparable to the response rates for groups I and II. The true value for the proportion of harvest from the late season (5200 license stubs were sampled) was greater than the predicted value and the value for groups I and II alone. The predicted value provided a slightly better estimate for this

index(?) than the value for groups I and II combined. The underestimation of the true value by the predictive equation results from the large difference in the statistic between group III and groups I and II. This may represent a situation similar in nature to the potential influence of hard-core non-respondents on estimates generated by the wave method (Filion 1980). The predicted value for kill rate was almost identical to the true value and closer to the true value than the kill rate for groups I and II combined. It should be noted that the kill rate for group III was not significantly different (statistically) from the kill rates for group II or groups I and II combined. The later result may be a function of the small sample size for group III.

The use of group III data was made as if this group of data was received directly after groups I and II data. It is unknown whether or not this actually occurred because a number of license stubs could not be accounted for. The use of data from group III supports the use of the wave method to improve index estimates but is only an incomplete test because the stubs from group III represent only a portion of those received too late. If the majority of the unaccounted for stubs had actually been received prior to those from group III, the exact relationship of predicted proportions to true proportions would likely be different. Irrespective of the above, the data of group III provides evidence that the index estimates are improved by the wave method.

The equation developed to control the impact of incomplete sampling on kill rate was used to estimate total harvest. Although the available evidence does not support a difference in kill rate between the license stubs sampled (groups I and II) and the license stubs not sampled (group III represents a portion of those), the lack of statistical support likely results from the small sample size of group III. It is assumed that the stubs not sampled were received after groups I and II and it is therefore expected that these stubs represent individuals who purchased their licenses late, had less opportunity to hunt, may be less interested in hunting, and were likely less successful as a result. The estimated total harvest of 936 moose was lower than the non-response bias adjusted estimate of 950 moose (based on the stubs sampled). If some of the unaccounted for license stubs were lost and not included with groups I and/or II (i.e., the

above assumption violated), it is possible that the estimate of 950 moose would be the more accurate estimate. The use of 936 moose as the best estimate has both theoretical and limited support from available data; however, assessment is incomplete relative to which estimate is most accurate.

Geographic Distribution

The large proportion of hunters sampled should ensure an accurate assessment of the geographic distribution of general moose hunters for the 1986 season. Any bias in the proportions due to licensees not sampled would likely relate to an underrepresentation of those localities geographically close to Game Hunting Areas with winter seasons (eg., G.H.A. 26). This statement is made on the premise that the vendors who return their stubs the latest are likely those who sell their licenses the latest (e.g., the stubs from hunters who resided in Manigotagan (G.H.A. 26) were returned after 20 January 1987 or relatively late).

Winnipeg residents purchased licenses for the 1986 general moose season at almost the same proportion as that estimated by Bossenmaier and MacPherson (1964) for resident moose hunters during the 1963 moose season (16.7%). The estimate of 16.7% was based on a sampling intensity of 10% of resident moose hunters and a response rate of 88.5%. The estimate was based upon the respondents to the random sample of hunters therefore the estimate would have overestimated the actual proportion of Winnipeg hunters if the response rate of Winnipeg hunters was greater than that of rural hunters (as found in this study).

The 2 estimates are not directly comparable because the estimate by Bossenmaier and MacPherson (1964) represents the proportion of Winnipeg residents from all resident moose hunters while the estimate from this study is based upon general moose hunters alone (although general moose hunters represent the greatest proportion of resident moose hunters). It is apparent that despite the difference in methodologies used to arrive at the estimates, the proportion of the resident moose hunters who reside in Winnipeg has not changed substantially since 1963.

Almost 1 in 5 hunters who purchased a general moose license were residents of Game Hunting Area 9. The only other G.H.A. whose residents

accounted for >10% of total licenses was G.H.A. 38 (Winnipeg). The potential bias relative to geographic location would also apply to the geographic distribution estimates generated for each G.H.A. (e.g., the proportion of hunters resident in G.H.A. 26 may be underestimated).

Response Rate by Geographic Distribution

The response rate of Winnipeg residents was greater than that of rural residents among those hunters who purchased licenses for the 1986 general moose season. Such a difference could be important to estimates because Winnipeg residents comprise a significant portion of the general moose hunters. The difference in response rate may be important for 2 reasons.

The differential response rate will be important if success rates are different for the 2 groups of hunters. Bossenmaier and MacPherson (1964) estimated that 20.7% of Winnipeg residents were successful as compared to 36.9% of rural residents for the 1963 moose season. Rural hunters may continue to be more successful than Winnipeg hunters. This difference, in combination with the greater response rate of Winnipeg hunters, would lead to underestimation of harvest.

The differential response rate will also be important if Winnipeg residents do not hunt as frequently in each G.H.A. as do rural resident moose hunters. Winnipeg residents would have comprised approximately 300 of the approximately 600 residents who hunted moose in G.H.A. 26 during 1986 (V. Crichton, Manitoba Wildlife Branch, pers. commun.). The close proximity of G.H.A. 26 to Winnipeg is likely responsible in part for the significant representation of Winnipeg residents in this G.H.A. Winnipeg residents would have represented a considerably lesser proportion of the residents hunting moose in many G.H.A.'s. This difference in distribution, combined with the greater response rate of Winnipeg hunters, will be particularly important to attempts to estimate the spatial distribution of hunters (by G.H.A.) and harvest for specific G.H.A.'s.

The problem which may result from differential response is of particular concern to a season like the general moose season where a hunter may choose to hunt in one or more of several G.H.A.'s. The following theoretical example illustrates how a differential response rate

may significantly influence harvest estimates (Table 55). Although the number of hunters and kill are exactly the same for the G.H.A.'s in this theoretical example, the estimates are highly biased and incorrect as a result of differential response rate.

Table 55. Theoretical impact of differential response on estimation of hunter distribution and harvest.

	G.H.A. A	G.H.A. B
Theoretical number of hunters	100	100
Theoretical number of kills	50	50
Theoretical number of reports (response rate)	40(40%)	10(10%)
Estimated number of hunters	.8(40/50) x 200 = 160	.2(10/50) x 200 = 40
Estimated number of kills	160 x .5 = 80	40 x .5 = 20

The above potential bias may lead to significant error in estimates for specific G.H.A.'s. The very low response rates (relatively) recorded for a number of communities (in concert with the relatively high response rates recorded for other communities) could be very important if the success rates of hunters from these communities are considerably different from those hunters who respond to the questionnaire. Those communities with high response rates are generally located outside the boundaries of G.H.A.'s open to the general moose hunter while the communities with low response rates are located inside or on the boundaries of these G.H.A.'s. It is to be expected that resident hunters living within or adjacent to these G.H.A.'s would be more likely to hunt within the G.H.A.'s and might be more successful than those hunters who reside outside the G.H.A.'s.

The Kill Rate as an Index for Past Estimates

An estimate of kill rate from general moose questionnaire data

must be considered an index rather than an exact estimate when response rate is low (eg., 58.9% as recorded in this study) and sampling of license stubs is incomplete (eg., 85.8% during 1984 as compared to 94.9% in this study). If sampling was complete and response rate was 100%, a kill rate would have to be treated with caution because the potential influence of response bias is unknown.

Some of the information critical to assessment of past estimates of kill rate is presented in Table 54. This table includes information for the 1974 moose season and for the 1980 to 1986 general moose seasons. The data for this table comes from Anonymous (1974), Vanderpont (1981, 1982, 1983, 1984, 1985), Hummelt (1986), and from this study. Sampling intensity varied considerably from 22% (1980) to 50% (1985, 1986) during this period. Sampling intensity impacts upon the precision of kill rate estimates (i.e., all other things being equal, a greater sampling intensity will result in tighter confidence limits) but would likely have a relatively minor impact upon accuracy of the estimates given the significant influence of both non-response bias (in particular) and incomplete sampling bias. An attempt to increase accuracy through increased sampling intensity will be a non-productive exercise when estimates are inaccurate primarily as a result of biases inherent to the methodology.

The kill rate estimate for 1974 should have been a reasonably accurate estimate (disregarding the potential influence of response bias for the moment). It appears that 100% of the available stubs were sampled. The 1974 season differed from the 1980 to 1986 seasons in that individuals had to apply for the opportunity to hunt moose in Manitoba. A list of successful applicants resulted from which all individuals were available for sampling purposes. It appears that 3 mailings were conducted (P. Westhorpe, Manitoba Wildlife Branch, pers. commun.) and a response rate of 87.2% was attained. Only 80.1% of the total licensees from the sample were used to construct the estimates; however, this proportion is relatively high.

The kill rate estimates for the years 1980 to 1986 would be expected to be considerably more biased than that for 1974 and should not be compared directly to the estimated kill rate for 1974 (the bias could be too great). It would appear that kill rate estimates for the years 1980 to

1986 were collected under conditions of reasonably similar methodology. Sampling intensity varied considerably (22% to 50%) but it would appear that only 1 mailing was conducted. The number of mailings conducted for 1980 was not indicated by Vanderpont (1981); however, the relatively high response rate (57.1%) suggests that 2 mailings may have been conducted. The proportion of licenses sampled varied between 85.8% and 94.9% for the years 1980, 1981, 1984, 1985, and 1986 (it was not possible to determine this statistic for 1982 and 1983). The relationship between kill rate index and the number of licenses sampled from this study was: Kill rate index = .2665119 - .00001168 X Number of licenses sampled. An equivalent relationship is: Kill rate index = .2665052 - .0006276 X Percentage of licenses sampled. If the assumption is made that this relationship (developed from data from this study) provides a reasonable estimate of the relative impact of incomplete sampling for any given year, then the kill rate index would be 21.27% for 85.8% sampling completeness and 20.70% for 94.9% sampling completeness. This represents a difference of only 2.7% (0.57 divided by 21.27) in the kill rate index between the minimum and maximum levels of sampling completeness. The above assumption is essentially an assumption of constant relative (proportional basis) bias. This assumption dictates that for any given year at any given sampling completeness, the proportional error relative to the true kill rate index is constant irrespective of absolute differences in the kill rate indices between years. This assumption can be explained best by the following theoretical example which considers quite different absolute kill rate indices, the result of radical differences in hunter success (Table 56). With this assumption, the relationship between the kill rate indices (for the 2 years) for any level of sampling completeness is the same regardless of absolute values. It must be recognized that even if this assumption is a good one for past data, changes in methodology in terms of the return of license stubs to the Wildlife Branch could potentially result in violation of the assumption.

Response rates were available for 1980, 1981, and 1986 alone because the number of satisfactory returns was the only information available for 1982 to 1985. The proportion of satisfactory returns was available for 1980 to 1986; however, it must be recognized that all returns

Table 56. Theoretical example illustrating impact of assumption of constant proportional error on ability to compare kill rate indices.

Year	True kill rate index (100% sampling completeness)	Error at 80% sampling completeness	Absolute value of error	Kill rate index at 80% sampling completeness
1	0.20	5%	0.20 X 0.05 = 0.01	0.19
2	0.10	5%	0.10 x 0.05 = 0.005	0.095

were deemed satisfactory and utilized for 1986. The proportion of satisfactory returns varied between 43.3% and 56.2% for this period. The proportion was relatively high for 1980 (56.2%) but reasonably constant for 1981 to 1986 (43.3% to 48.9%). The relationship between kill rate and the number of questionnaires returned (as a measure of return rate) from this study was: Kill rate = .243506 - .0000243 X Number of questionnaires (maximum of 2551 questionnaires). An equivalent relationship is: Kill rate = .24328 - .0006171 X Response rate (%). If the assumption of constant relative bias is made for this relationship, then the kill rate (index) would be 21.66% for a response rate of 43.3% and 20.86% for a response rate of 56.2%. This represents a difference of 3.7% (0.80 divided by 21.66) in these indices for the year with the minimum and maximum response rates. The absolute value of 0.80 would result in a difference of 43 moose if 5374 licenses had been purchased (0.008 x 5374). It is important to recognize that the assumption of constant bias could be violated if the reasons for not responding were to change over time (eg., if, through education, response became 100% for those former non-respondents who hadn't responded because they were unsuccessful and had thought the Wildlife Branch was not interested).

The kill rate estimate for 1981 results from a more complete sample but lower response rate (satisfactory returns) than the kill rate estimate for 1984. The greater sampling completeness could tend to make the 1981 estimate less biased than the 1984 estimate but the lower response rate could tend to make the 1981 estimate more biased. These differences operate

in a compensating manner thereby making the kill rate indices for the 2 years more comparable. The absolute impact on the kill rate index was similar for both sampling completeness (0.57) and response rate (0.80), therefore the compensating effect would be real as opposed to simply theoretical but insignificant in effect. It is useful to note that the year with the lowest sampling completeness (1984) did not have the lowest response rate and the year with the lowest response rate (1981) did not have the lowest level of sampling completeness among the 5 years (1980, 1981, 1984, 1985, 1986).

The difference was 2.7% of the kill rate index for the minimum and maximum levels of sampling completeness. The difference was 3.7% of the kill rate index for the minimum and maximum response rates. The maximum impact of the 2 biases would be approximately 7.0% (they are not directly additive) of the kill rate index; however, the compensating effect would result in the kill rate indices for the 5 years being more comparable. This magnitude of potential error is not great; however, the calculation of this error is based upon 2 equations developed from only 2 data points (each) for only 1 year. The accuracy of these lines-of-best-fit is unknown (i.e., How much variability exists about the lines?) for 1986 and it is not known how accurately the equations would predict for other years (i.e., constant relative bias is assumed). There is no doubt that the 2 equations would not predict perfectly for the 5 years examined. Under these conditions, it is not unreasonable to expect a maximum error of 15% or more among the 5 kill rate indices. This error (in the ability to compare indices) would be additional and separate from the potential uncertainty represented by the 95% confidence limits.

Another important assumption implicit to the use of these kill rates as indices is that the relationship between the true kill rate and the kill rate index is linear and passes through the origin (i.e., 0,0). This assumption allows index values to be compared directly (i.e., a doubling in the kill rate index from one year to the next reflects a doubling in the true kill rate). The validity of this assumption is unknown for kill rates estimated for the general moose season. Under these conditions, comparison of kill rate indices among the years 1980 to 1986 should be made cautiously and only extreme differences should be noted. It is critical to note that

the discussion has related to kill rate indices for total kill. The ability to compare indices for winter kill and specific G.H.A.'s could be quite different.

Questionnaire-Generated Estimates of Kill Rate and Their Use for the Management of Moose

(a) Accuracy and Comparability

Howard and Larche (1977) recognized the need for annual questionnaire surveys to estimate moose harvest and recommended that harvest should fall within 95% confidence limits which did not exceed 20% of the harvest estimate (i.e., ± 20% of the estimate). This recommendation likely assumed that the estimate is unbiased and therefore accurate (non-response bias is not discussed by Howard and Larche (1977) although they alluded to the results of Bossenmaier and MacPherson (1964) when they indicated that success rates prior to 1965 were probably inflated because they were derived from voluntary license returns). The estimates of kill rate would have been quite inaccurate for those years examined in Table 54 with the exception of 1974. Accuracy, although advantageous, is not always necessary to the proper management of wildlife (eg., see Stearns (1975) and Soprovich (1985) relative to aerial population estimates which are generally minimum population estimates and indices to change). If kill rate was a good index (comparable between years, linearly related to the true kill rate, the linear function passing through the origin), it could be used to reflect relative change in kill rate and harvest.

If the management objective is to determine the influence of management strategies (eg., harvest strategies) and efforts on the kill rate and harvest, then a good index would be useful as a management tool. A poor index could result in incorrect inference under these conditions. If the management objective required accurate estimates of kill rate and harvest (eg., to assess the impact of licensed harvest relative to other forms of mortality on moose populations, to be used as an estimate of licensed harvest in an add/subtract ungulate model), then an index may not be adequate. Even if the management objectives do not require accurate estimates of kill rate, it is necessary to test the accuracy of the index

periodically to ensure that the bias is consistent over time. It is obvious that a consistent methodology which maintains consistent levels of sampling completeness and response rate is critical for the kill rate estimate to be used as an index and for the kill rate index to be compared between years. Given the option, an accurate estimator is obviously best because the bias and the assumptions necessary to use of an index are eliminated.

(b) The Best Index for Manitoba

It is likely that no matter how much time and effort is expended in trying to achieve accurate estimates, kill rate will be biased to some degree and can be considered an index. The bias associated with ambiguous data, response bias associated with data which is not ambiguous, and the impact of changing hunter demography are a few examples of potential bias which may not be consistent over long periods of time. The best index for Manitoba would be obtained consistently over long periods of time - once a method is determined, divergence from that method should be made only after the ramifications on the index have been considered. Strict adherence to a methodology, once determined, will ensure that "the continuity of the data is not destroyed by 'occasional improvements' in techniques" (Fraser 1985). Those biases which can be controlled should be controlled, those biases which cannot be controlled should be standardized through methodology.

The kill rate and harvest of moose by licensed hunters is one of the pieces of data important to the management of moose and other ungulates in Manitoba. Additional information which is collected by the hunter questionnaire is also very useful (eg., hunter effort). The questionnaire can be an extremely useful tool for the collection of this information; however, estimates which result must be used cautiously (i.e., information relative to response rate, in particular, and completeness of sampling must be considered in assessment of the accuracy of the estimates). For questionnaire-generated data, the accuracy of the estimates and the ability to compare between years is within the influence of game managers to a large extent. A decision to send out 1 less mailing for a given season will result in a less accurate and less comparable estimate. The ability to influence the quality of questionnaire estimates exceeds considerably the

ability to influence the quality of estimates of other data important to the management of moose (eg., population estimates, estimates of harvest by native Manitobans, estimates of kill by poachers).

Overestimation of true harvest has been considered to be a conservative estimate with the concurrent belief that it is better to err on the conservative side. The potential for bad management decisions is minimized only if the error is made consistently. An historical overestimate of kill would hardly be considered a good error if subsequent accurate estimates (via improved methodology) resulted in the belief that a population was being underharvested and a decision was made to increase harvest to "past levels" (i.e., the levels which were estimated to have occurred). The key to good decisions is to have comparable estimates firstly and accurate estimates secondly (accurate estimates being comparable).

RECOMMENDATIONS

1. Maximize response rate for the general moose season questionnaire and for all questionnaires with response induction techniques (see Filion 1980). Consider multiple mailings, changes in the format and wording of both the questionnaire and the information which accompanies the questionnaire, and the use of registered mail for non-respondents (or a sample of non-respondents). A significant increase in response rate is critical to the use of the general moose questionnaire to estimate kill by Game Hunting Area.
2. Develop standardized methodologies specific to the general moose season questionnaire and questionnaires for other seasons. Include information relative to the number of mailings to be conducted, when mailings would be sent out relative to the end of the season, the time between mailings, etc. Adhere to these methodologies over time.
3. Ensure that all license stubs are received by the Wildlife Branch, perhaps through frequent communication between individuals processing the license stubs and individuals conducting the questionnaire program.
4. Standardize (and hopefully minimize) the bias which accompanies the questionnaires (not just moose) which are ambiguous through the

application of a group of rules designed to handle these data. Rules should not place a great deal of burden upon the individual who is inputting the data to make judgments (these individuals have generally had limited knowledge relative to hunting seasons during recent years). This will result in errors in the estimates (eg., indicated hunters in G.H.A. 26 during the early season); however, the handling of such errors should be explained in the methodology section of each annual report.

5. Eliminate the bias which results from incomplete sampling. Determine the cause of the problem through discussion with Wildlife and Fisheries Licensing. If the problem results from vendors who continually choose to submit their returns late, then perhaps such vendors should be deleted from the list.
6. Make vendors responsible for ensuring that the names and addresses which are submitted to Wildlife and Fisheries Licensing are both complete and legible. Penalize vendors who consistently submit illegible or incomplete stubs (either by not paying vendors their per-license fee or by deletion from the list of vendors).
7. Consider having hunters apply for a general moose license if the above difficulties cannot be resolved. This would provide the Wildlife Branch with accurate names and addresses for all hunters who choose to hunt during the general moose season. This option should be considered a last resort because license sales would likely decrease in number and hunters would be inconvenienced somewhat.
8. Strongly consider amalgamation of the G.H.A.'s for the general moose season into larger management units for which hunters would apply for a license. This option would provide timely and accurate names and addresses for sampling purposes and would circumvent the problem caused by differential geographic response.
9. Make estimates available by 15 March to be used for season-setting purposes. Generate estimates at that date for:
    (a) all the questionnaires which have been returned and
    (b) a constant proportion of the total sample of licensees (eg., estimates at a return rate of 40%).

    The later estimate would allow reasonable comparison between years

which might have different response rates by 15 March. Collect additional data beyond 15 March such that a final estimate could be made (eg., to 30 April or beyond). Compare estimates generated on the basis of data obtained by 15 March and final estimates to allow prediction of final estimates from early estimates (once a sufficient number of years of data are available).

10. Motivate individuals to respond by making them aware of the importance of their response and involving them in the process of management of their wildlife. This might be accomplished, in part, through contact (written and/or personal) with hunters from those communities from which response is poor. A brief summary report (harvest by species and G.H.A.) might be handed out to those hunters who purchase licenses to hunt big game animals. Such a report would serve to inform hunters of the impact of recreational hunting on animal populations, provide information of interest to <u>each individual</u> (harvest by G.H.A.), and would explain why individual response is important.
11. A prize might be offered as an inducement to response (eg., for those individuals who respond by 15 March, a draw for a prize could be made). It would be necessary to inform all individuals that they would be eligible for such a draw irrespective of whether they were successful in tagging an animal (Mason et al. (1983) speculate that monetary incentives could motivate individuals to respond quickly with little regard to quality of response). Once in place, it would be important to maintain this incentive on an annual basis.
12. It may be necessary to contact non-respondents in the future (dependent upon the attainable response rate). The inclusion of the licensees telephone number on the license stub would assist the feasibility of exercising this option.
13. Test statistically estimates which reflect the effort required to tag a moose (days per kill) to determine if they vary between years. Such a statistic is important because success alone may remain stable while hunter effort may increase due to a population which is declining in numbers. This statistic could be useful as an index of population change, particularly where population estimates are conducted infrequently (note that such a statistic would be a fairly gross

index).

14. Investigate the influence of response bias on both ambiguous and unambiguous questionnaire data. Redesign of the questionnaire should eliminate some of the bias through the elimination of redundant questions.
15. Conduct a study to assess the accuracy of the wave method both in space (different G.H.A.'s) and time (several years). Results consistent with those found in this study could allow less intensive questionnaire surveys (fewer mailings) and quick estimates of true harvest, etc.
16. Move the location of the number on the questionnaire such that it cannot be rendered illegible when the questionnaire envelope is peeled away.
17. Do not change the boundaries of G.H.A.'s so that realistic annual comparison of harvests by geographic area can be made.

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Appendix I. Questionnaire and accompanying information sent to each licensee in the sample.

NOTE: IF YOU DID NOT HUNT IN THE 1986 MOOSE SEASON,
PLEASE CHECK HERE ☐ AND RETURN.

1. During which months did you hunt moose? Sept./Oct./Nov. ☐ Dec. ☐
2. Did you party hunt *(Did another hunter sign your licence?)* Yes ☐ No ☐
3. Did you use your game tag? No ☐ Yes: Sept./Oct./Nov. ☐ Dec. ☐
   (Party Hunters: Do not mark "Yes" unless your game tag was used.)
   If no, please go to question 6.
4. In which game hunting area did you tag your moose? Game Hunting Area No. ☐
5. Was the animal you tagged an:
   1) adult male ☐ 3) immature male* ☐
   2) adult female ☐ 4) immature female* ☐
   *born in 1986
6. Please list the number of days you hunted moose by Game Hunting Area:

Game Hunting Area Number *(Please see map for reference.)*	Number of Days Hunted *Sept./Oct./Nov.*	*Dec.*
G.H.A. ☐	☐	☐
G.H.A. ☐	☐	☐

MG 1183-M

2519

BUSINESS REPLY MAIL
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Canada Post Postes Canada 12

Postage Will be Paid By

Department of Natural Resources
Box 24
1495 St. James St.
Winnipeg, Manitoba
R3H 9Z9

Manitoba Moose Hunter:

Each year we select a random sample of moose licencees and request their assistance by completing a questionnaire. Please return the completed postcard as soon as possible; even if you did not hunt or kill a moose. Your reply will assist us in our management efforts and enable us to provide a sound population base for future years.

From our last year's survey we estimated that 4,700 general and 1,590 special moose hunters hunted for a total of 38,500 days and harvested 1,330 moose.

NO POSTAGE OR ENVELOPE IS REQUIRED. YOUR SIGNATURE IS NOT NECESSARY.

SEPTEMBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

OCTOBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

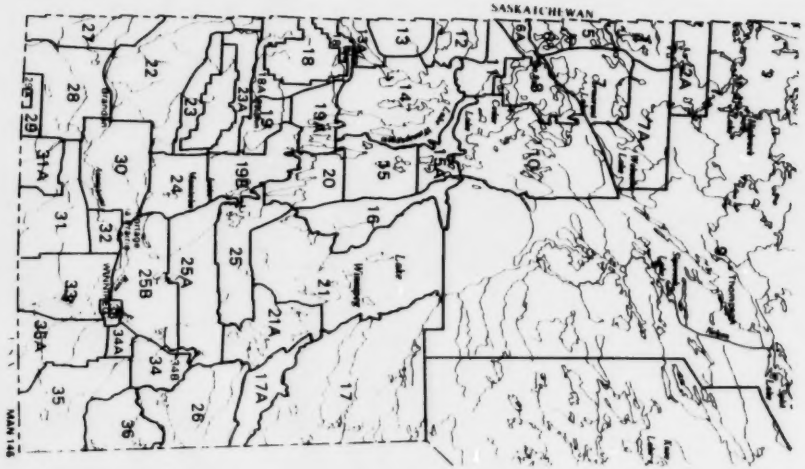
THANK YOU

NOVEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

DECEMBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			



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Appendix II. Questions asked of non-respondents.

DATA SHEET * NON-RESPONSE BIAS

Name_____

Address from vendor stub_____

_____

_____

_____

Hunter number _____

Did you hunt moose during 1986? Yes ____ No ____

During which months did you hunt? Sept./Oct./Nov. ____ Dec. ____

Did you party hunt? (Did another hunter sign your license?) Yes ____ No ___

Did you use <u>your</u> game tag? (If this individual party hunted, ensure that he/she used his/her tag) No ____ Yes: Sept./Oct./Nov. ____ Dec. ____

In which G.H.A. did you tag your moose? _____

Was the animal you tagged an: adult male ____ adult female ____

immature male ____ immature female ____

Note that an immature animal is a calf born in 1986.

Please list the number of days you hunted moose by G.H.A.

G.H.A.	Number of days	
	Sept./Oct./Nov.	Dec.
_____	_____	_____
_____	_____	_____
_____	_____	_____

Did you receive a questionnaire in the mail? Yes ____ No ____

Did you receive two questionnaires in the mail? Yes ____ No ____

Did you send a questionnaire in to us? Yes ____ No ____

If they did not submit a questionnaire, ask:

Why did you not submit a questionnaire? _____

_____

_____

Additional comments: _____

_____

_____

Appendix III. Rules used by Knudsen for handling missing or confusing data found in moose hunter questionnaires.

1. No Game Hunting Area given.

If a geographic location was given which unambiguously specified the location at which hunting occurred, the correct G.H.A. was determined and entered. If a location was given which was on the boundary of two G.H.A.'s with open seasons, the two G.H.A.'s were entered alternately as the location appeared. For example, the first time "Bissett" was given as a location, G.H.A. 17A was entered. The second time, G.H.A. 26 was entered. If no G.H.A. could be determined, "M" was entered.

2. Two Game Hunting Areas given.

If both G.H.A.'s had open seasons, the total days hunted were divided equally between the two areas. If one of the areas did not have an open general season, only the G.H.A. with the open season was entered.

3. Number of days hunted not given.

If "one week" was given, 6 days were entered. If nothing was given, the entry was alternately 3 and 4 days, because these were the approximate median values for completed questionnaires.

4. Tag reported as "Not used", but data on kill given.

The tag report was given precedence, and the data on the killed moose was assumed to be a moose tagged by a hunting partner. All of these cases were hunters who reported hunting in a party.

5. Game Hunting Area not open to general season.

If a closed G.H.A. or a draw G.H.A. was given, "M" was entered.

6. Entire month given as number of days hunted.

If the respondent stated that all of the month was hunted, 24 was entered (4 weeks at 6 days per week). If "SEPT", "OCT", or "NOV" was given, the assumption was that the respondent thought the name of the month was to be given, and the response was handled as in item 3, above.

7. "DID NOT HUNT" checked, but more data given.

The information on the hunt was given precedence. Many respondents made this mistake, probably because one line at the top of the questionnaire reads:

"PLEASE CHECK HERE ☐ AND RETURN"

and can be read without reference to the line above it, which reads:

"NOTE: IF YOU DID NOT HUNT IN THE 1986 MOOSE SEASON"

Appendix IV. Rules used by Soprovich for handling missing or confusing data found in moose hunter questionnaires.

1. Missing and/or confusing data which results in little to no ambiguity.

   (i) Hunter indicated not hunting (checked box) and answered no to question 2 and/or question 3.
   Treatment: Hunter did not hunt.

   (ii) Hunter indicated not hunting (checked box) but supplied answers to the rest of the questions.
   Treatment: Hunter did hunt (checking of box ignored).

   (iii) Question 1 not answered but answer to question 6 supplied.
   Treatment: Question 6 answers used to indicate which seasons (early, late) individual hunted in.

   (iv) Question 4 not answered when a moose was indicated as killed (questions 3 and 5 answered); only one Game Hunting Area indicated in question 6.
   Treatment: Game Hunting Area in question 6 used for answer to question 4.

   (v) Hunter wrote both month and days in one box for question 6 (e.g., Oct., 2 days).
   Treatment: Hunter hunted two days during October.

2. Missing and/or confusing data which results in little to significant ambiguity. Method of treatment may result in serious errors - lack of treatment may result in serious errors.

   (i) Question 3 (use of game tag).

      (a) Hunters indicated hunting during both early and late season but did not supply season of kill.
      Treatment: Hunter killed and tagged moose during late season.
      Assumption: Hunter had not tagged a moose during early season so continued to hunt during late season. This rule will result in a bias towards overestimation of late-killed moose but it is likely that a greater bias towards underestimation of late-killed moose would develop in the absence of a treatment.

      (b) Hunter indicated killing and tagging a moose but did not supply season of kill in question 3. Season hunted supplied in question 1 and/or 6 (only one season supplied).
      Treatment: Hunter killed and tagged moose during season supplied by question 1 and/or 6.

(ii) Question 4 (G.H.A. in which moose was tagged).

(a) Game Hunting Area not supplied but one Game Hunting Area supplied in question 6.
Treatment: Game Hunting Area from question 6 used.

(b) Supplied a Game Hunting Area closed for the season during which hunting occurred - one adjacent G.H.A. was open.
Treatment: Used the Game Hunting Area which was open during the season hunted.
Assumption: Hunter would remember when he hunted reasonably well but could easily provide the wrong G.H.A. given the small scale of the map supplied with the questionnaire.

(c) Supplied a Game Hunting Area closed for the season during which hunting occurred - several adjacent G.H.A.'s were open.
Treatment: G.H.A. treated as unknown.

(d) Supplied a Game Hunting Area which was open only by draw (Special).
Treatment: Used a Game Hunting Area which was open during the season hunted (same assumption as above).

(e) Game Hunting Area not supplied but one G.H.A. supplied in question 6.
Treatment: Used G.H.A. from question 6.

(f) Game Hunting Area not supplied in question 3 or elsewhere.
Treatment: G.H.A. treated as unknown.

(g) Game Hunting Area indicated as either of two Game Hunting Areas, one with an open season and one with a closed season during the period hunted.
Treatment: Used G.H.A. with the open season.

(iii) Question 5 (Age and sex of tagged moose).

(a) Age and/or sex of moose tagged was not a legal bag for the season and G.H.A. where hunting was reported to have occurred.
Treatment: Age and sex left as reported. The report may have been wrong or the hunter may have bagged an illegal animal. No assumption made in this case.

(iv) Questions 3, 4, and 5.

(a) Indicated that game tag was not used in question 3; answer provided to question 4, question 5 or both questions 4 and 5.

Treatment: Treated as having not used game tag; other responses ignored.

(b) Reported using game tag in question 3 but did not provide answers to questions 4 and 5.
Treatment: Treated as a kill (tag used), used Game Hunting Area supplied in question 6 if only one G.H.A. supplied; treated as unknown otherwise; question 5 treated as unknown.

(c) Answered yes and no to question 3; either provided no answer to questions 4 and 5 or provided answers to question 4, question 5, or both questions.
Treatment: Treated as having not used game tag; other responses ignored.

(d) Did not answer question 3; provided answers to questions 4 and 5.
Treatment: Treated as having not used game tag; other responses ignored.

(e) Did not answer questions 3, 4, and 5.
Treatment: Treated as having not used game tag.

(v) Question 6.

(a) Game Hunting Area in question 6 does not include Game Hunting Area from question 4.
Treatment: G.H.A. from question 4 included.

(b) G.H.A. indicated in question 6 was not open; one adjacent G.H.A. was open.
Treatment: G.H.A. changed to adjacent open G.H.A.

(c) G.H.A. indicated in question 6 was not open (eg., G.H.A. 25); several adjacent G.H.A.'s were open.
Treatment: G.H.A. treated as unknown.

(d) G.H.A. indicated in question 6 was not open; no adjacent G.H.A.'s open.
Treatment: G.H.A. treated as unknown.

(e) Hunter indicated in question 1 and question 6 that had hunted in either an early or a late season; the G.H.A. indicated in question 6 did not have such a season.
Treatment: G.H.A. changed to adjacent G.H.A. which did have such a season.
Assumption: Hunter would remember when he hunted reasonably well but could easily provide the wrong G.H.A. given the small scale of the map supplied with the questionnaire (e.g., hunter indicated hunting two weeks in G.H.A. 26

during Sept./Oct./Nov. but season for G.H.A. was from Dec. 1-13; changed to G.H.A. 17A).

(f) G.H.A. not provided and also not indicated in question 4.
Treatment: G.H.A. treated as unknown.

(g) G.H.A. not provided but indicated in question 4.
Treatment: Used G.H.A. provided by question 4.

(h) The number of days was provided in one of the boxes (for either the early or late season). The season was in conflict to the season indicated in question 1 or questions 1 and 3.
Treatment: Season in question 1 given precedence. The number of days was moved to appropriate box.

(i) Season provided in question 6 and question 3 in conflict with season provided in question 1.
Treatment: Season provided in question 1 changed to that for the other two questions.

(j) Reported information in boxes under "Number of Days Hunted".

(i) 2 hours.
Treatment: 1 day.

(ii) 1/2 day.
Treatment: 1 day.

(iii) 1 week.
Treatment: 6 days (additional weeks treated as 6 days per week).

(iv) 8-10 days.
Treatment: 9 days (the mean was taken).

(v) Same G.H.A. written in both G.H.A. boxes; two different numbers written in both boxes for the same season (early season only).
Treatment: Both numbers added together to result in one value for the G.H.A.
Assumption: Separate days refer to separate months as hunters during the early season could hunt in as many as three months.

(vi) One date written in box (e.g., Sept. 22).
Treatment: 1 day.

(vii) Several dates written in box (e.g., Dec. 2, Dec. 13).

Treatment: 2 days.

(viii) Reported a value in a box for the early season (or a range); wrote Dec. in a box for the late season and indicated hunting during the late season in question 1.
Treatment: The value from the box for the early season was used as the value for the number of days hunted during the late season; no days were recorded as having been hunted during the early season.

(ix) Reported hunting 30 days; the maximum possible was 24 days.
Treatment: Value changed to 24 days.

(x) Wrote "All" for early, late or both seasons for number of days.
Treatment: Used the maximum number of days possible for the specific season.

(k) Two G.H.A.'s reported but only one value for the number of days.
Treatment: Split the number of days between the two G.H.A.'s; if the value was odd, one G.H.A. randomly assigned the extra day.

(l) Reported hunting in two G.H.A.'s, one of which was not open; reported number of days for both G.H.A.'s.
Treatment: Added the number of days together and assigned them to the open G.H.A.

(m) Reported hunting in either early or late season in question 1; reported days in both seasons in question 6.
Treatment: The number of days were left; treated as having hunted during both seasons.

(n) Reported hunting in both seasons in question 1; reported days in only one season in question 6.
Treatment: The number of days was left; treated as having hunted during one season.

(o) Number of days not indicated.
Treatment: Input as a zero and adjusted manually later (computer program would underestimate number of days hunted if number of days input as unknown or zero).

(p) Hunter had hunted in more than two G.H.A.'s.
Treatment: Additional G.H.A. data input on next record (computer program would not handle more than two G.H.A.'s per record).

Appendix V. Geographic distribution of hunters who purchased a license for the 1986 general moose season (from license stubs).

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Alexander	1		1
Alonsa	1	8	9
Altamont	5		5
Angusville	1	1	2
Anola	14	12	26
Arborg	53	13	66
Arden	2	1	3
Arnaud	2	1	3
Arnes	1	3	4
Ashern	20	3	23
Ashville	1		1
Aubigny	3		3
Bagot	1		1
Baldur	5		5
Balmoral	6	1	7
Barrows	29		29
Beausejour	23	16	39
Belair	1	1	2
Belleview		1	1
Bellsite	3	2	5
Benito	3	1	4
Binscarth	3	2	5
Birch River	26	11	37
Birds Hill	1	1	2
Birnie		1	1
Birtle	4	12	16
Bissett	6	15	21
Bloodvein	3		3
Boissevain	3	2	5
Bowsman	13	4	17
Brandon	30	16	46
Broad Valley	1	1	2
Brochet	1		1
Brookdale	1	2	3
Camper	1		1
Camperville	31	3	34
Camp Morton	3		3
Carberry	4	7	11

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Carman	5	3	8
Cartwright	2		2
Cayer	1	1	2
Channing	2		2
Chisel Lake	1		1
Churchill	38	9	47
Clandeboye	7	1	8
Clanwilliam	1	2	3
Cormorant	47	7	54
Cowan	11	2	13
Cranberry Portage	100	5	105
Crane River	1		1
Cross Lake	6		6
Cypress River	1		1
Dallas	9		9
Darlingford	1		1
Dauphin	52	15	67
Deloraine	13	1	14
Dominion City		2	2
Dropmore		1	1
Duck Bay	39	3	42
Dufresne	3		3
Dugald	16	8	24
Easterville	6		6
East Selkirk	7	2	9
Eddystone	2		2
Eden		1	1
Elgin		1	1
Elie	1	3	4
Elkhorn	2		2
Elma	6	2	8
Elm Creek	6		6
Emerson		2	2
Erickson		1	1
Eriksdale	14	6	20
Ethelbert	7	2	9
Fairford		2	2
Fannystelle		1	1
Fisher Branch	46	4	50
Flin Flon	184	13	197
Fork River	8	5	13
Foxwarren	3	1	4

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Franklin		3	3
Fraserwood	5	1	6
Garland	2		2
Garson	2	1	3
Gilbert Plains	5	2	7
Gillam	76	6	82
Gimli	40	6	46
Giroux	2		2
Gladstone	6		6
Glenella		1	1
Gods Lake Narrows	5	3	8
Grand Marais	2	7	9
Grand Rapids	37	11	48
Grandview	1		1
Granville Lake	2		2
Graysville		2	2
Great Falls	2	2	4
Grunthal	2	1	3
Gunton	11		11
Gypsumville	6	1	7
Hadashville		1	1
Hamiota	1		1
Hartney		1	1
Hazelridge	4	2	6
Headingly	6	2	8
High Bluff	4		4
Hilbre	7	1	8
Hodgson	2	2	4
Holland	1		1
Homewood		1	1
Ile Des Chenes	6		6
Ilford	3		3
Inglis	1		1
Inwood	9	2	11
Island Lake	2	1	3
Kelwood		2	2
Kenville	1		1
Killarney		2	2
Kinosota	1		1
Kleefeld	3	2	5
Kola		2	2

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Komarno	2		2
Koostatak	1	1	2
La Broquerie	2		2
Lac du Bonnet	33	12	45
Lake Francis	4		4
Landmark	5	1	6
Langruth		1	1
La Riviere	1		1
Laurier	2		2
Leaf Rapids	139	12	151
Libau		4	4
Limestone	2	1	3
Little Bullhead	8	1	9
Little Grand Rapids	4	1	5
Lockport	9	3	12
Loon Straits	1		1
Lorette	13	4	17
Lowe Farm		1	1
Lundar	6	3	9
Lyleton	1	4	5
Lynn Lake	137		137
MacGregor	9	2	11
Mafeking	57	2	59
Malonton		1	1
Manigotagan		10	10
Manitou	4		4
Marquette	6	4	10
Mather	1		1
Matheson Island	19	1	20
Matlock	5	5	10
McCreary	2	1	3
Meadow Portage	5	2	7
Medora	1		1
Meleb	1		1
Melita		1	1
Miami	1	3	4
Miniota		1	1
Minitonas	20	2	22
Minnedosa	3	3	6
Minto	1	2	3
Moosehorn	5	2	7
Moose Lake	12	7	19
Morden		7	7

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Morris	1	2	3
Mulvihill	1		1
Narcisse	2		2
National Mills	3		3
Neepawa	11	3	14
Nelson House	2		2
Nesbitt	1	1	2
Newdale		2	2
Niverville	2	3	5
Norway House	18	5	23
Notre Dame de Lourdes		4	4
Oakbank	5	1	6
Oak Bluff	1		1
Oakville	2	2	4
Ochre River	2		2
Otterburne		2	2
Paint Lake	2		2
Paungassi	2		2
Pelican Rapids	5		5
Petersfield	3	8	11
Pierson	1	3	4
Pikwitonei	7		7
Pilot Mound	3	1	4
Pinawa	8	6	14
Pine Dock	2		2
Pine Falls	38	8	46
Pinemuta	4		4
Pine River	41	1	42
Pipestone		2	2
Plumas	1	1	2
Plum Coulee	2	1	3
Pointe du Bois	3	1	4
Poplarfield	8		8
Poplar River	10	1	11
Portage la Prairie	36	4	40
Powerview	12	2	14
Princess Harbour	8		8
Red Sucker Lake	3	2	5
Rennie	3	2	5
Renwer	2		2

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Reston	7	1	8
Richer	15	2	17
Richmond, B.C.[a]	1		1
Riding Mountain	1	1	2
River Hills	1	1	2
Rivers	1	1	2
Riverton	42	8	50
Roblin	1	5	6
Roland	1		1
Rorketon	2	3	5
Rosa	1	2	3
Roseau River	1	1	2
Roseisle	2		2
Rossburn	1		1
Russell	5	1	6
St. Adolphe	7		7
St. Ambroise	3		3
St. Claude	6		6
St. Eustache	3		3
St. Francois Xavier	1		1
St.-Georges	8		8
St. Jean Baptiste	1	1	2
St. Laurent		1	1
St. Leon	1		1
St. Malo	9	3	12
St. Martin	6	3	9
St. Norbert		3	3
St. Pierre-Jolys	2	1	3
Ste. Agathe		5	5
Ste. Anne	18	8	26
Ste. Rose du Lac	9	4	13
Salts Point		1	1
San Clara	1	1	2
Sandridge		2	2
Sandy Bay	1		1
Sandy Hook	2		2
Sandy Lake	2	1	3
Sarto	1		1
Scanterbury	1	2	3
Seddons Corner		2	2
Selkirk	60	38	98
Seven Sisters	7	1	8
Seymourville	1		1
Shellmouth		1	1

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Sherridon	7		7
Shilo	22	6	28
Shoal Lake		1	1
Sifton	5	1	6
Sinclair	1		1
Sperling	1		1
Snow Lake	98	24	122
Somerset	1		1
Souris	5	7	12
South Indian Lake	10		10
Southport	1		1
Starbuck	10	1	11
Stead		1	1
Steeprock	3		3
Steinbach	33	11	44
Stephenfield	2	1	3
Stonewall	12	7	19
Stony Mountain	7	1	8
Sundance	13	3	16
Swan Lake	1		1
Swan River	30	10	40
Tadoule Lake	1		1
Teulon	16	1	17
The Pas	305	20	325
Thicket Portage	6		6
Thompson	471	21	492
Thornhill		1	1
Tourond		2	2
Toutes Aides	1	1	2
Traverse Bay		1	1
Treherne		1	1
Tyndall	8	6	14
Valley River	2		2
Vassar	2		2
Vermette	1	1	2
Victoria Beach	2		2
Virden	6	4	10
Vogar	1		1
Wabowden	34	5	39
Waldersee		1	1
Wallace Lake	1		1
Wanipigow	2	2	4

Location	Number of hunters		
	Group I (license stubs received by 20 January 1987)	Group II (license stubs received by 15 February 1987)	Total
Wanless	11		11
Warren	6	2	8
Wasagaming	1		1
Waterhen	2	9	11
Wawanesa	1		1
Westbourne	3		3
Westgate	1		1
West St. Paul		1	1
Whitemouth		4	4
Winkler	1	9	10
Winnipeg	641	190	831
Winnipeg Beach	10	3	13
Winnipegosis	74	9	83
Woodlands	8	3	11
Woodridge		2	2
TOTAL	4100	965	5065

[a]Individual had purchased a resident license with a Richmond, B.C. address.

Appendix VI. The allocation of hunters between Game Hunting Areas for those locations situated on a boundary.

Location	Game Hunting Area	Number of Hunters
Ashern	21	12
	25	11
Ashville	18A	1
	19	0
Baldur	31	2
	31A	3
Birch River	13A	18
	14	19
Bloodvein	17	1
	17A	2
Brandon	28	23
	30	23
Camperville	14	17
	19A	17
Carman	31	4
	33	4
Cranberry Portage	4	53
	7	52
Dauphin	19	34
	23A	33
Erickson	22	1
	23	0
Gillam	9	41
	3	41
Hadashville	35	1
	36	0
Ilford	9	2
	3	1
Inwood	25A	5
	25B	6
Killarney	28	1
	31A	1
Mafeking	13	29
	14	30
Niverville	33	3
	35A	2
Otterburne	33	1
	35A	1
Pine Falls	34	23
	34B	23
Poplar River	9	5
	17	6
Powerview	34	7
	34B	7
Ste. Rose du Lac	19	7
	19B	6

Location	Game Hunting Area	Number of Hunters
Whitemouth	35	2
	36	2
Winnipeg Beach	25A	7
	25B	6

Appendix VII. Number of respondents to the first or second mailing and non-respondents by location for the questionnaire mailed to a sample of 1986 general moose hunters. Response rate is the proportion of hunters responding to either the first or second mailing of the questionnaire. The data represents the combined sample of both groups of hunters. Response rates are calculated for those locations from which ten or more hunters were sent questionnaires.

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Alexander			1	
Alonsa	3		1	
Altamont	3			
Angusville			1	
Anola	4	2	6	50.0
Arborg	15	4	12	48.4
Arden	3			
Arnaud			1	
Arnes	3	1		
Ashern	5		3	
Ashville			1	
Aubigny	1			
Baldur	3			
Balmoral	2			
Barrows	1	2	12	20.0
Beausejour	14	3	9	65.4
Belleview	1			
Bellsite	1		3	
Benito	1		1	
Binscarth	1		1	
Birch River	7	3	8	55.6
Birtle	3		5	
Bissett	3		8	27.3
Bloodvein	2		1	
Boissevain	2	1	1	
Bowsman	7	1	4	66.7
Brandon	12	2	8	63.6
Broad Valley	1			
Brookdale	3			
Camperville	2	1	16	15.8
Carberry	2		3	
Carman	1		3	
Cartwright	1			
Cayer	1			

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Chisel Lake			1	
Churchill	11	4	12	55.6
Clandeboye	4		1	
Clanwilliam	3			
Cormorant	5	2	19	26.9
Cowan	4		3	
Cranberry Portage	22	3	26	49.0
Crane River			1	
Cross Lake			2	
Dallas	2		1	
Darlingford		1		
Dauphin	14	7	15	58.3
Deloraine	3	1	5	
Duck Bay	5		13	27.8
Dufresne	1			
Dugald	5		5	50.0
Easterville			2	
East Selkirk		4	2	
Elgin	1			
Elie	1		1	
Elkhorn		1		
Elma	1		2	
Elm Creek	3	1		
Emerson			1	
Eriksdale	4	1	4	
Ethelbert	2	1	2	
Fisher Branch	8	3	10	52.4
Flin Flon	41	17	40	59.2
Fork River	2		4	
Foxwarren	2		1	
Franklin	2			
Fraserwood	1	2	2	
Garson		1	1	
Gilbert Plains	1		2	
Gillam	19	5	19	55.8
Gimli	15	2	8	68.0
Giroux	2			
Gladstone	3	1		
Glenella			1	
Gods Lake Narrows	3		2	
Grand Marais	2		2	
Grand Rapids	12	1	13	50.0
Grandview	1			

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Granville Lake			1	
Graysville			1	
Great Falls	1	1		
Grunthal		1		
Gunton	1	2		
Gypsumville	2		2	
Hamiota			1	
Hartney			1	
Hazelridge	1		2	
Headingly	2		2	
High Bluff	1			
Hilbre	3	1	2	
Hodgson	4		5	
Homewood	1			
Ile Des Chenes	2			
Ilford	2			
Inglis		1		
Inwood	1		3	
Island Lake		1		
Kelwood			1	
Kenville		1		
Killarney	1			
Kinosota	1			
Kleefeld			2	
Kola	1			
Komarno		1		
Koostatak	1			
La Broquerie			1	
Lac du Bonnet	10	2	7	63.2
Lake Francis	2		1	
Landmark		1	3	
Langruth			1	
La Riviere			1	
Laurier			1	
Leaf Rapids	36	8	32	57.9
Libau	1			
Limestone			2	
Little Bullhead	1	1	1	
Little Grand Rapids	1		2	
Lockport	3		3	
Lorette	6	1	4	63.6
Lowe Farm	1			
Lundar	4			

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Lyleton	1	1	3	
Lynn Lake	32	5	28	56.9
MacGregor	3		2	
Mafeking	7	2	17	34.6
Manigotagan	1		4	
Marquette	2		2	
Mather	1			
Matheson Island	4	3	5	58.3
Matlock	2		2	
McCreary	1			
Meadow Portage	1	1	2	
Meleb			1	
Miami	1	1	1	
Minitonas	7		5	58.3
Minnedosa	2			
Minto	1			
Moosehorn	2		2	
Moose Lake	3		8	27.3
Morden	2	2		
Morris	1		1	
Mulvihill	1			
Neepawa	5	1	1	
Nelson House	1			
Newdale	1		1	
Niverville	2			
Norway House	5	1	6	50.0
Notre Dame de Lourdes	2			
Oakbank	1		2	
Oakville	1	2		
Otterburne	1		1	
Paint Lake	1			
Pelican Rapids			3	
Petersfield	1	1	4	
Pierson	2			
Pikwitonei	1		3	
Pilot Mound			2	
Pinawa	5		2	
Pine Dock			1	
Pine Falls	9	4	8	61.9
Pinemuta	2		1	
Pine River	9	2	9	55.0

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Pipestone			1	
Plumas			1	
Plum Coulee			1	
Pointe du Bois			2	
Poplarfield	2	1	1	
Poplar River	2	2	2	
Portage la Prairie	13	3	6	72.7
Powerview	2	1	6	
Princess Harbour	3			
Red Sucker Lake	2		1	
Rennie	1	1		
Renwer			1	
Reston			3	
Richer	2		7	
Richmond, B.C.[a]			1	
Riding Mountain			1	
Rivers			1	
Riverton	11	4	11	52.7
Roblin	3		1	
Roland			1	
Rorketon	2		1	
Rosa		1	1	
Roseisle	1			
Russell	2		1	
St. Adolphe	1	1		
St. Ambroise		1	1	
St. Claude	3		1	
St. Eustache	1	1		
St.-Georges	4		2	
St. Jean Baptiste			1	
St. Laurent	1			
St. Leon	1			
St. Malo	5	1		
St. Martin	1		3	
St. Pierre-Jolys	1	2		
Ste. Agathe	2			
Ste. Anne	8		5	61.5
Ste. Rose du Lac	4	1	2	
Sandridge	2			
Sandy Hook	2			
Sandy Lake	1		1	
Scanterbury	1		1	
Seddons Corner		1		
Selkirk	22	3	22	53.2

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Seven Sisters	4			
Shellmouth			1	
Sherridon	2		1	
Shilo	8	1	3	75.0
Sifton		1	3	
Sinclair	1			
Sperling	1			
Snow Lake	31	5	23	61.0
Somerset	1			
Souris	5	1		
South Indian Lake	1		5	
Starbuck	3	1	3	
Stead			1	
Steeprock		1		
Steinbach	9	3	11	52.2
Stephenfield			2	
Stonewall	4		2	
Stony Mountain	3		2	
Sundance	2	3	3	
Swan River	11	2	9	59.1
Tadoule Lake			1	
Teulon	7	1	2	80.0
The Pas	70	18	78	53.0
Thicket Portage	1		2	
Thompson	104	23	124	50.6
Tourond	1			
Treherne	1			
Tyndall	4	1	3	
Valley River		1		
Vassar		1		
Vermette	1		1	
Victoria Beach	1			
Virden	4			
Wabowden	8	3	12	47.8
Wallace Lake			1	
Wanipigow			2	
Wanless			3	
Warren		1	3	
Waterhen	1	1	3	
Westbourne	1			
Westgate			1	
Whitemouth	1		1	
Winkler	4	1	2	

Location	Number of hunters			Response rate (%)
	First mailing	Second mailing	Non-respondents	
Winnipeg	213	46	143	64.4
Winnipeg Beach	3	2	2	
Winnipegosis	13	9	22	50.0
Woodlands	4	1	1	
Woodridge			1	
TOTAL	1161	277	1108	56.5

[a]Individual had purchased a resident license with a Richmond, B.C. address.